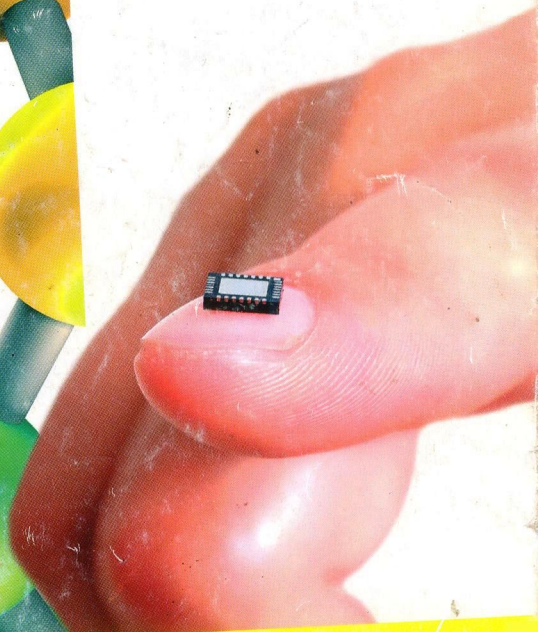


MANORAMA

# TELL ME WHY

No:94



# nanotechnology

TECHNOLOGY THAT WILL SHAPE THE FUTURE



# MANORAMA TELL ME WHY

July 2014 • Volume: 8 • No: 7

FROM THE HOUSE OF MAGIC POT, THE WEEK, MANORAMA YEARBOOK,  
VANITHA & THE MALAYALA MANORAMA DAILY

## HIGHLIGHTS

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## A Promise for the Future

“Why can’t we write all the 24 volumes of the Encyclopedia Britannica on the head of a pin?” This question, raised by the great scientist Richard Feynman, became the cradle for a revolutionary idea - the technology of the future - nanotechnology. It is the study and control of matter at the nanoscale, rearranging atoms and molecules.

Nanotechnology has made marvelous contributions in many diverse fields, ranging from computer science to medical science.

This issue of Tell Me Why takes you to the wonder world of nanotechnology.



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# SMALL IS BIG

## What is Nano?

The Greek word for dwarf is 'nano'. In nanotechnology, a 'nanometre' is a billionth of a metre, and each nanometre is only three to five atoms wide. Things on this scale cannot be seen even with ordinary microscopes. Objects this small require a special tool called a scanning probe microscope.

1 metre = 100 centimetres

1 centimetre = 10 millimetres

1 millimetre = 0.000001 nanometre

Tell Me Why

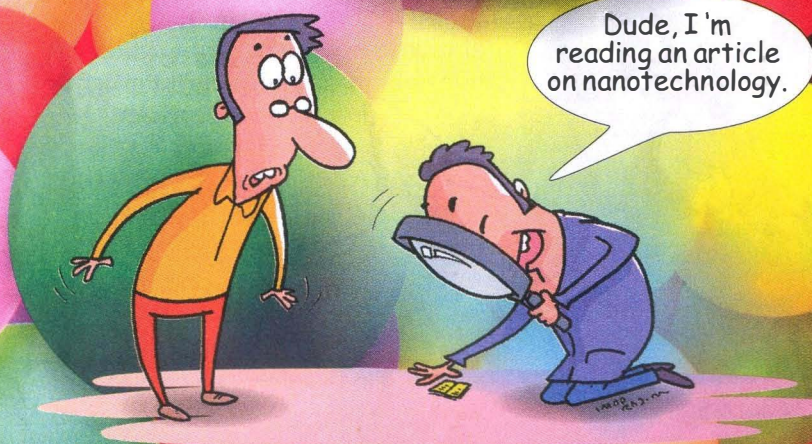


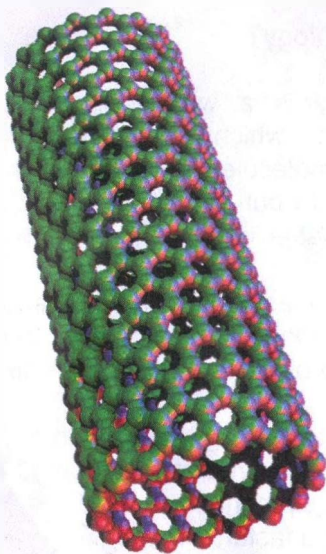
## What is nanotechnology?

**N**anotechnology is a wonderful new technology in which scientists rearrange atoms and molecules of matter to nano specifications. Or, to put it differently, the use and control of tiny matter is called nanotechnology.

The tiny matter is referred to as nanoparticles. These particles are measured in nanometres. Matter at the nanoscale has different properties from the same matter in bulk form.

In modern times, nanotechnology has become increasingly important. It has many uses from developing sports equipment to medical applications, and is a faster, cheaper, and better technology for use in many applications.





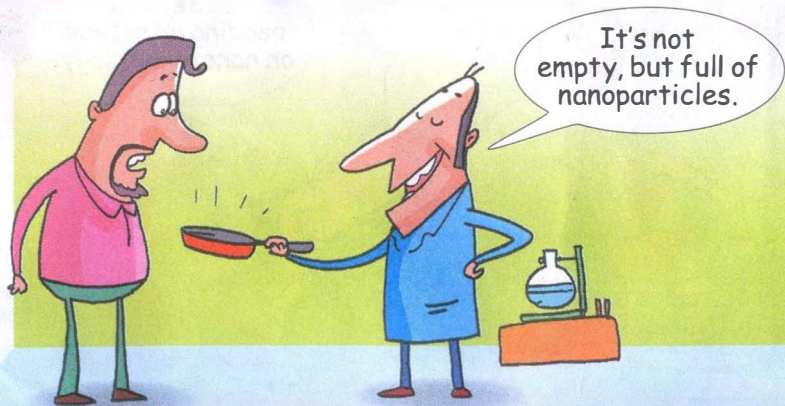
*Carbon Nanotube*

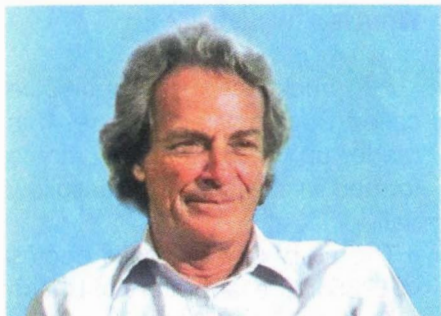
## What are the milestones in nanotechnology ?

The first important milestone in nanotechnology occurred in 1985 with the invention of 'bucky-ball' or Carbon 60 molecule, by a group of scientists.

In 1988, some scientists proved that it is possible to move atoms and molecules in a planned manner. The next important step was the invention of the carbon nanotube in 1991.

Since then, nanotechnology has made it possible to manufacture lighter, stronger, and program-mable materials that require less energy to produce, than conventional materials.





*Richard Feynman*

### **Why is Richard Feynman associated with nanotechnology?**

**R**ichard Feynman was a Nobel Prize winner (1965) and a brilliant physicist. In 1959, he introduced the concept of nanotechnology when he gave a talk titled 'There is Plenty of Room at the Bottom' in which he spoke of a day when things could be miniaturized so that huge amounts of information could be made to fit into tiny spaces, and machinery could be made smaller and more compact.

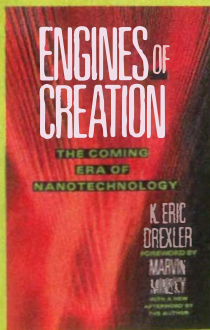
He believed that all the 24 volumes of the Encyclopedia Britannica could be contained on a pinhead with the use of nanotechnology. His ideas were the inspiration for future scientists to pursue this technology to its present form.



## **CURIOUS FACT**

### **Founder**

K. Eric Drexler's 'Engines of Creation,' is justly renowned as the book that launched a continuing debate in scientific and academic circles about the advent of nanotechnology, and its promises and threats. Drexler is considered to be the founder of nanotechnology.







*Buckyball*

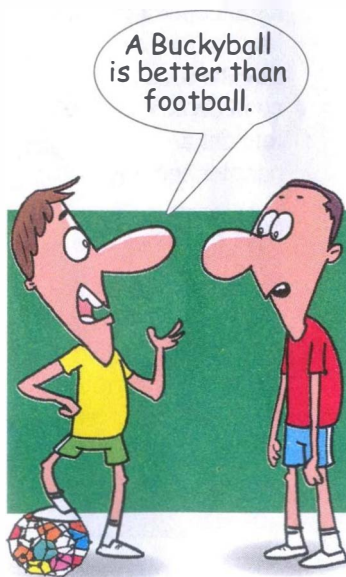
## What is a buckyball?

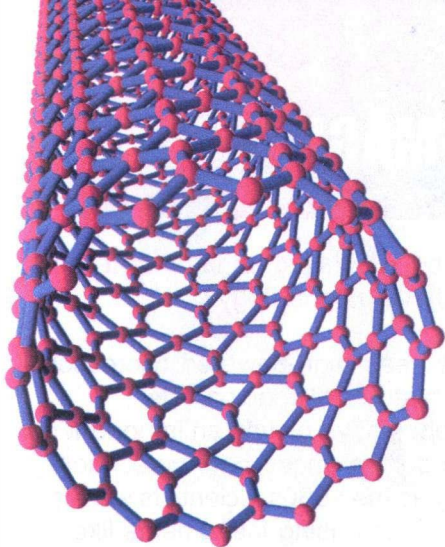
**A** buckyball is a molecule called Buckminsterfullerene. It is made up of 60 carbon atoms formed in the shape of a hollow ball.

The story of buckyballs begins in 1985 in the laboratory of British astronomer cum chemist Harold Kroto. Looking at 'red giant' stars billions of miles away, Kroto was puzzled by the long chains of carbon atoms that his instruments told him these stars emitted.

Later, he joined American scientist Richard Smalley and Robert Curl, who were studying similar chains or clusters of atoms in the laboratory. Together, they devised instruments to study these clusters. They put carbon in a helium-filled chamber, and vaporized it with a laser. The resulting carbon molecules held exactly 60 carbon atoms, arranged into a roughly spherical shape and was called buckyball, because of its shape that resembles a football.

Kroto, Curl, and Smalley were awarded the Nobel Prize for Chemistry in 1996, for this great discovery.





*Nanotube - Another View*



## CURIOUS FACT

### The Word Nanotechnology

Prof. Norio Taniguchi of Japan coined the word 'nanotechnology' in 1974. A brilliant scientist, he was using machines which had tolerances in terms of a micrometre at that time.

### Why was the invention of the carbon nanotube important ?

A carbon nanotube is a giant molecule of carbon atoms which has a cylindrical framework with a radius of about a nanometre. This is where its name comes from.

Nanotubes are categorized as single-walled nanotubes, and multi-walled nanotubes. A single walled carbon nanotube is one hundred times stronger than steel. With their extraordinary strength, and fascinating knack for conducting electricity and heat, nanotubes are finding applications in everything from cancer treatments to hydrogen cars.

These structures of carbon may be tiny—a nanotube's diameter is about 10,000 times smaller than a human hair—but their impact on science and technology has been enormous.

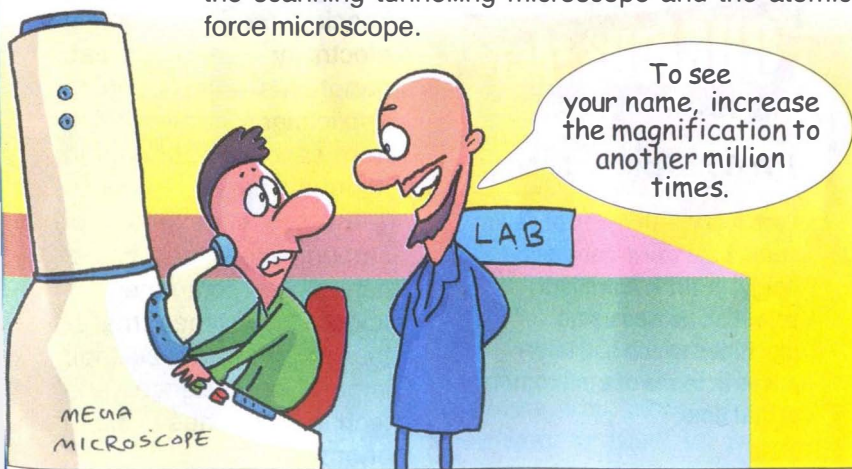
# MICRO MAGIC

**Why have microscopes played an important role in the development of nanotechnology?**

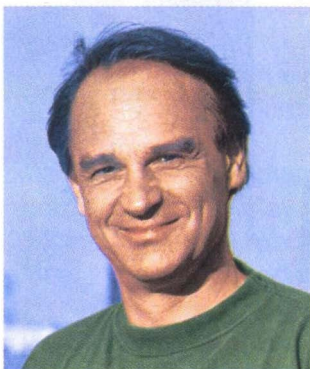
**N**anoscientists need high-powered microscopes to see the surface features of nano particles.

In fact, microscopes have played an important role in opening the door to modern nanotechnology. Beginning as early as the 1930s, scientists were able to see the nanoparticles using instruments like the electron microscope.

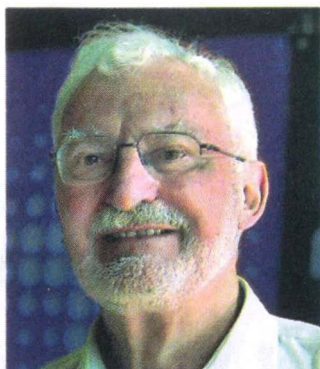
The electron microscope was first developed by German engineers Ernest Ruska and Max Knoll in 1932. Electron microscopes yield much greater resolution than the older light microscopes. The most recent and notable developments in microscopy are the scanning tunnelling microscope and the atomic force microscope.







*Gerd Binnig*



*Heinrich Rohrer*



## STAR FACT

### Sumio Iijima

'Carbon nanotube' was discovered in 1991 by Sumio Iijima. His carbon nanotube was a one-atom thick sheet of graphite, rolled into a tube with a diameter of one nanometre. He won the inaugural 2008 Kavli Prize in Nanoscience for his discovery.

### Why has the scanning tunnelling microscope helped the development of nanotechnology?

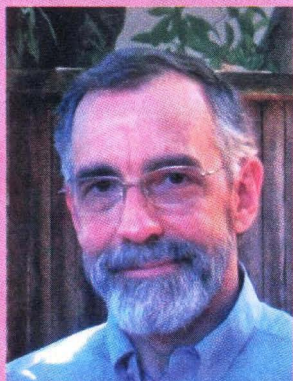
In the late 20<sup>th</sup> century, German-born physicist Gerd Binnig and Swiss physicist Heinrich Rohrer invented the scanning tunnelling microscope, or STM.

Its resolution is so great that it can resolve a single atom. The underlying principle of the STM is the tunnelling of electrons, between the sharp tip of a probe, and the surface of the sample under study.

The invention of STM has given us stunning insights into the world of nanotechnology.

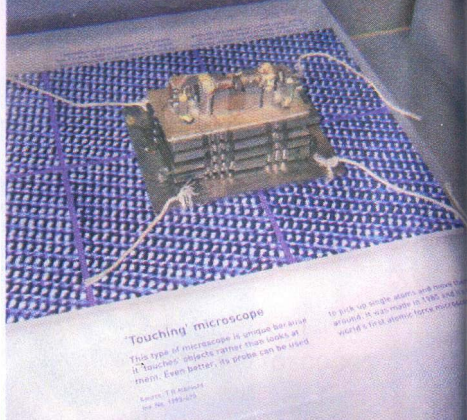


## STAR FACT



### Mr. Nano

Eric Drexler is often described as “the founding father of nanotechnology”. He was the first to publish a technical paper, and book on molecular nanotechnology. For this reason, he is also called Mr. Nano.



### The First AFM

#### What is AFM?

**A**FM stands for atomic force microscope. Gerd Binnig, Calvin Quate and Christoph Gerber invented the first atomic force microscope in 1986. It is a type of high resolution scanning probe microscope that has a resolution that you can measure in fractions of a nanometer.

The AFM ‘feels’ the atoms rather than ‘sees’ them. The AFM is one of the foremost tools for imaging, measuring, and manipulating matter at the nanoscale.

It is very versatile, and this versatility has led to an explosion in the number of scientists using the instrument.

## Why is a nanomanipulator very useful?

**T**he nanomanipulator system is used for working with objects on an extremely small scale.

The nanomanipulator uses advanced computer graphics to display the scanned surface to the user. A robot arm enables the user to feel, and modify the surface.

In short, this instrument provides a scientist with the ability to examine, and study objects as small as single molecules.

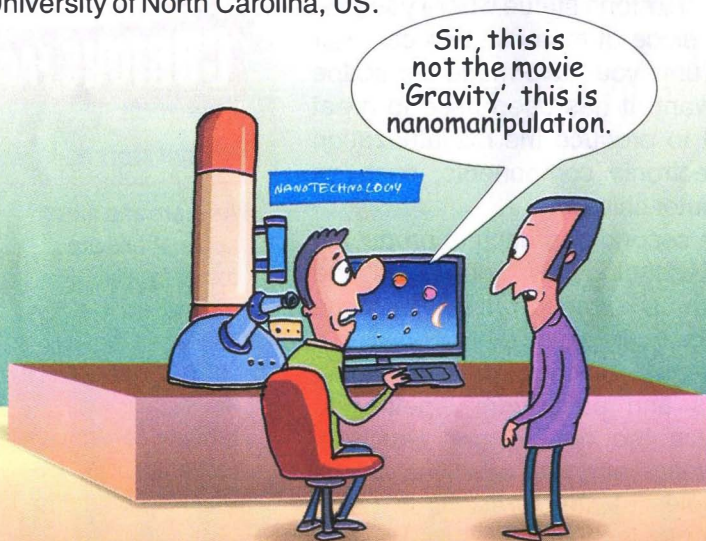
The system was designed by the Centre for Computer Integrated Systems for Microscopy and Manipulation at the University of North Carolina, US.



### CURIOUS FACT

#### STM

In 1989, Don Eigler was the first to manipulate atoms using a scanning tunnelling microscope.





# NANOMATERIALS: WONDERS UNLIMITED

## How are nanoscale objects made?

**T**wo approaches can be taken when making something at the nanoscale. They are known as the top down approach, and the bottom up approach.

The top-down approach is like making a stone statue where you take a big piece of material, and carve or cut it until you have made the shape you want. It has been used to great effect to produce the miniaturization of electronic components, such as computer chips.

The second approach to producing nanotechnology is known as the bottom-up approach. It is the same approach one would take to building a house, i.e, taking lots of building blocks and puts them together to produce the final bigger structure. Cosmetics and fuel additives are all examples of structures made using bottom-up techniques.



## CURIOUS FACT

### Global Market

As more and more applications are found for nanowires, it is estimated that by 2015, the global market for these tiny wonders could reach 1.8 billion US Dollars.

POLITICS  
SPORTS  
TECHNOLOGY  
BUSINESS



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## STAR FACT

### MEMS

**MEMS stands for microelectromechanical systems. These are machines with moving parts that contain both electrical and mechanical parts. They are made with nanotechnology, and are thinner than a human hair.**

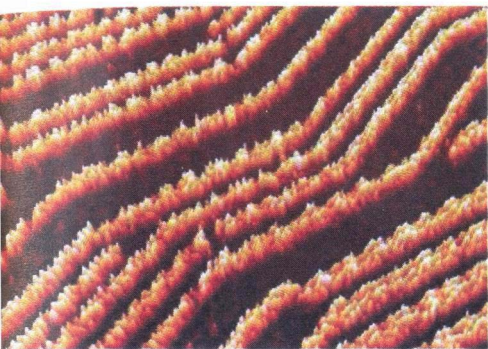
### What is self-assembly?

**S**elf-assembly is a process in which pre-existing components that are disorganized, interact with each other to form an organized structure.

This process can be classified either as static self assembly, or as dynamic self assembly. Static self-assembly is when the ordered state does not require the release of energy. Dynamic self-assembly is when the ordered state requires release of energy.

Self-assembly occurs in nature, as in the case of cells. Examples of self-assembling system include weather patterns, and solar systems.





*The Magnified Image of Self-assembled Super Molecular Chains*

### What is positional assembly?

**P**ositional assembly is a technique that has been suggested as a means to build objects, devices, and systems on a molecular scale using automated processes.

Here, the components carry out the construction process by following programmed paths. It is a high precision form of self-assembly.

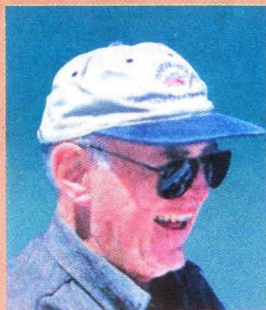
Positional assembly deals with the mechanics of moving molecular pieces into their proper relational places and keeping them there. Molecular robots are devices that do the positional assembly.



## STAR FACT

### Moore's Law

Moore's Law is a computing term which originated around 1970. This law states that processor speeds, or overall processing power for computers will double every two years. The law also stated that silicon transistors would become smaller and smaller. This has been made possible by nanoelectronics.



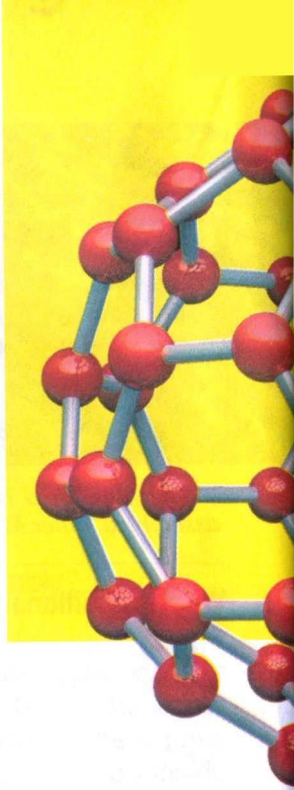
*Gordon Moore*

## Which are the major nanomaterials?

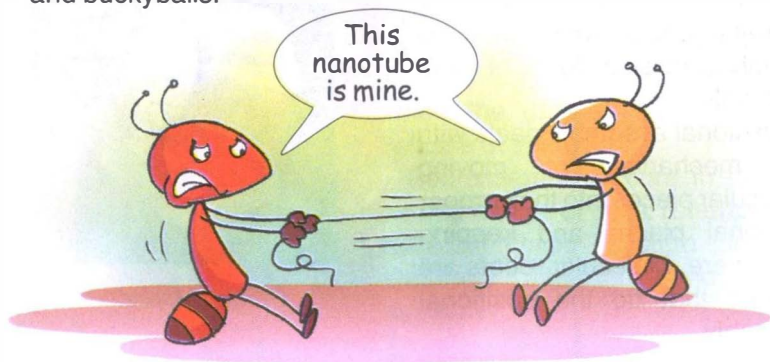
**N**anomaterials are chemical substances or materials that are manufactured and used at a very small scale - down to 10,000 times smaller than the diameter of a human hair.

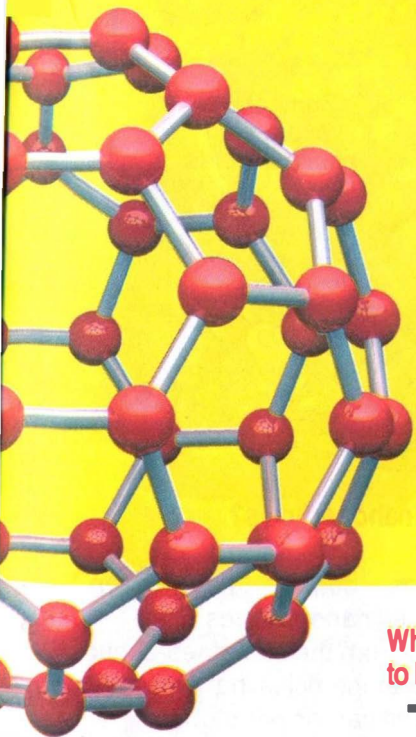
Nanomaterials have novel characteristics, such as increased strength, chemical reactivity or conductivity, compared to the same material without nanoscale features. Hundreds of products containing nanomaterials are already in use. Some examples are batteries, coatings, anti-bacterial clothing etc.

Carbon nanotubes are among the most exciting of nanomaterials. These rod-shaped carbon molecules are roughly one nanometre across. Although they're hollow, their densely packed structure makes them incredibly strong, and they can be grown into fibres of virtually any length. There are many other nanomaterials like nanoparticles, nanowires, nanocapsules, DNA chips, nanocrystals, and buckyballs.



*Nano Sphere of  
Carbon Atoms*





## STAR FACT

### Medieval Wonder

Nanotechnology is a modern phenomenon, but even in medieval times, nanoscale materials have been used like the gold and silver particles found in the stained glass windows of churches.

**When did the term 'nanoparticles' come to be in use?**

**T**he use and control of tiny matter is called nanotechnology. The tiny matter is referred to as nanoparticles. These particles are measured in nanometres and they have a size in between 1 and 100 nanometres.

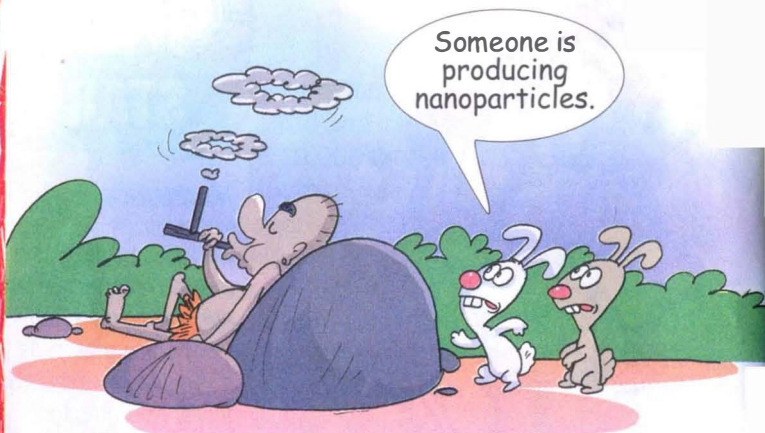
Nanoparticles were previously known as ultrafine particles. The new term 'nanoparticles' started being used only after the 1990s.

Some of these nanoparticles occur naturally as in the case of volcanic ash. Nanoparticles are also present in aerosols, suspensions, and emulsions.



*DNA Chip*





### What is the history of nanoparticles?

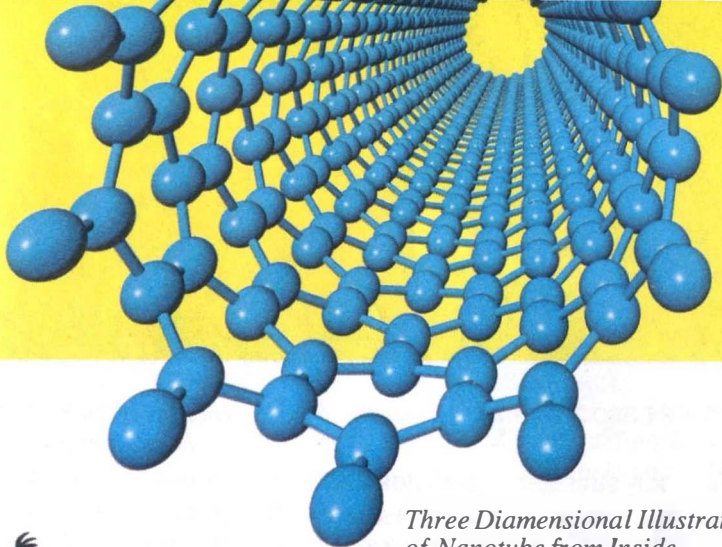
Since early times, humans have been producing carbon-based nanoparticles.

The smoke and soot from the campfires of our ancestors contained nanoparticles that are today known as fullerenes and carbon nanotubes.

Nanoparticles were used by artisans as far back as the ninth century in Mesopotamia for generating a glittering effect on the surface of pots.

Later, in the 11<sup>th</sup> to 13<sup>th</sup> centuries AD, the exceptional strength, remarkable sharpness, and beautiful patterns on the surface of the Damascus steel sword blades used by Saladin's troops may have been due to the presence of carbon nanotubes in the steel used.

In 1985, Richard Smalley found that stable clusters of 60 carbon atoms were produced when he shot a laser at a sheet of graphite, and nanotechnology in its present form was born.



*Three Dimensional Illustration of Nanotube from Inside.*



## STAR FACT

### Prey!

In 2002, Michael Crichton wrote a book, 'Prey,' which features an artificial swarm of nanorobots. These nanorobots develop intelligence and threaten their human inventors. The book created quite a sensation.

## Why are nanoparticles of great scientific interest?

Nanoparticles are important because they are a bridge between bulk materials and atomic structures.

While bulk materials have constant physical properties regardless of their size, in the case of nanoparticles, the size often dictates the physical and chemical properties. Thus, the properties of materials change as their size approaches the nanoscale.

Nanoparticles are important scientific tools that have been, and are being explored in various biotechnological, pharmacological, and pure technological uses.



## What are nanocrystals?

**N**anocrystals are particles so small that their width measures about  $1/80,000$  of the diameter of a single strand of hair. They are so light and so strong that NASA once said they theoretically could be used to build an elevator to the Moon.

Nanocrystals are roughly spherical, and the size and shapes of these crystalline particles can be controlled. The number of electrons they have can range from one to several thousands. Their size distinguishes them from larger crystals, and billions of nanocrystals can be accommodated on a pinhead.

Nanocrystals may be used to make super-strong and long-lasting metal parts. The crystals also may be added to plastics and other metals to make new types of composite structures for everything from cars to electronic devices.

### *Nanocrystals Under UV Excitation.*

---





## What are nanowires?

**N**anowires are simply, very tiny wires. They are composed of metals such as silver, gold, or iron, or semiconductors such as silicon, zinc oxide, and germanium.

Nanoparticles are used to create these little nanowires, which can have a diameter as small as a nanometre.

Nanowires have an amazing length-to-width ratio. Engineers and scientists tend to work with nanowires that are between 30 and 60 nanometres wide.

Nanowires can help to make smaller and faster computers in the near future. They can also be used to run self powered nanorobots that can fight diseases like cancer. Many different types of nanowires exist, including metallic, semiconducting, and insulating nanowires.



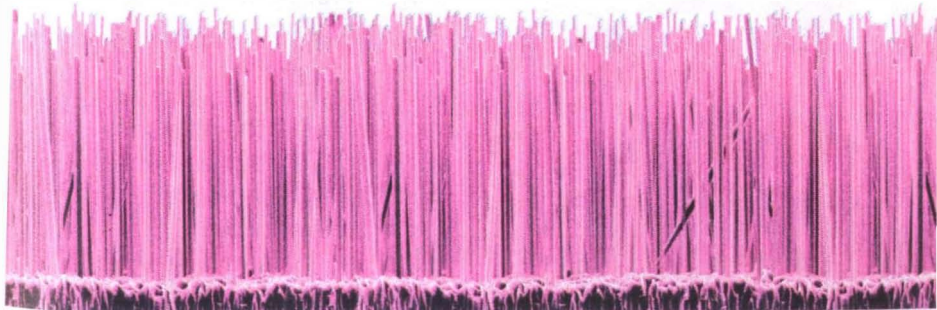
### CURIOUS FACT

#### IBM Magic

**The world's smallest computer logic circuit uses carbon nanotubes. It was built by IBM in 2001.**

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*Magnified Image of  
Nanowires*



# THE NANO AGE

A cartoon illustration of two ants sitting on a green patch of grass. The ant on the left is red with black stripes and is drinking from a red and yellow striped can. The ant on the right is orange with black stripes and is drinking from a blue and yellow striped can. Both ants are using very thin, transparent nano-straws. A speech bubble from the orange ant says, "This nano straw makes us proud."

This nano straw makes us proud.

## What are the applications of nanotechnology?

**N**anotechnology plays an important role in various fields like medicine, agriculture, electronics, and engineering.

In medicine, researchers are developing customized nanoparticles in the size of molecules that can deliver drugs directly to diseased cells in your body.

Nanotechnology holds some answers for how we might increase the efficiency of electronic devices, while we reduce their weight and power consumption.

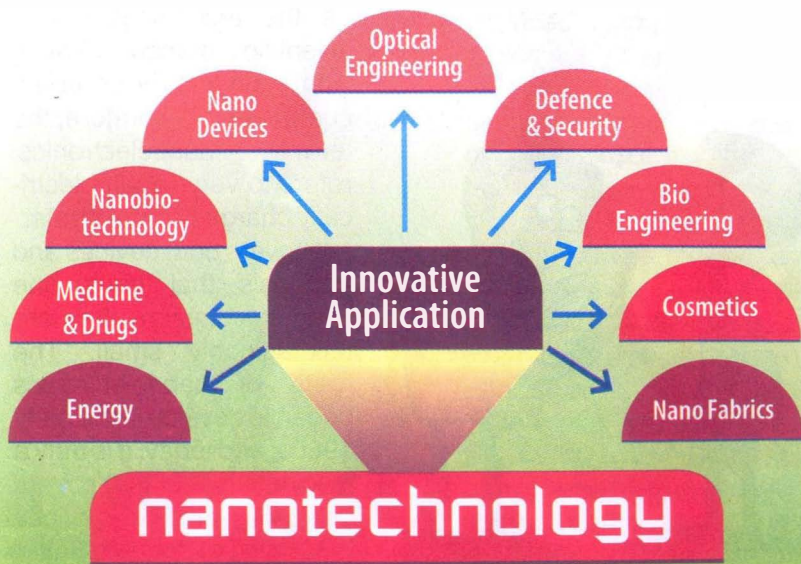
This technology is having an impact on several aspects

of food science, from how food is grown, to how it is packaged. Companies are developing nanomaterials that will make a difference, not only to the taste of food, but also in food safety.

Nanotechnology is being used to reduce the cost of catalysts used in fuel cells and also in solar cells.

Companies are currently developing batteries using nanomaterials. Nanotechnology may hold the key to making space-flight more practical, and can also improve air quality by improving the performance of catalysts used to transform vapours escaping from cars or industrial plants into harmless gases.

In addition, this technology can help in ensuring cleaner water as well as better sports equipment and improved fabrics.





# nanotechnology & ELECTRONICS

## What is meant by nanoelectronics?

**N**anoelectronics is an exciting field that is forecast to influence nearly every facet of our life. The term refers to the use of nanotechnology in electric components.

The first half of the word 'nano,' refers to the size of something, especially something very small.

'Electronics' may be defined as the technological and scientific branch dealing with electrical, or charged, components. Therefore, the term 'nanoelectronics' refers to very small, electrically charged components.

It covers both devices and materials that have one thing in common- they are unimaginably small. The roots of nanoelectronics began to develop in the early 1980s, and today, it is truly a fascinating field that covers designing medical devices to building better batteries.



**“Nanotechnology will be the future with nanoscience developing nanomaterials and devices.”**


**- Dr A.P.J. Abdul Kalam**

## **Why is molecular electronics an important branch of nanotechnology?**

**M**olecular electronics is a branch of nanotechnology that uses single molecules, or nanoscale collections of single molecules, as electronic components.

Conventional electronics have traditionally been made from bulk materials. In molecular electronics, the bulk material is replaced by single molecules. This way, billions of copies are made simultaneously, and the composition of molecules are controlled down to the last atom. The molecules utilized have properties that resemble traditional electronic components such as wires and transistors.

Molecular electronics is still in its infancy, but it brings hope for truly atomic scale electronic systems in the future.



Nano Bulb  
is ready.



## CURIOUS FACT

### Beauty and Quality

Nanotechnology also plays a role in the cosmetics industry. L'Oreal is a company that uses nanotechnology to transport active ingredients such as pure Vitamin E through the skin.

Which are some nanoelectronic devices?

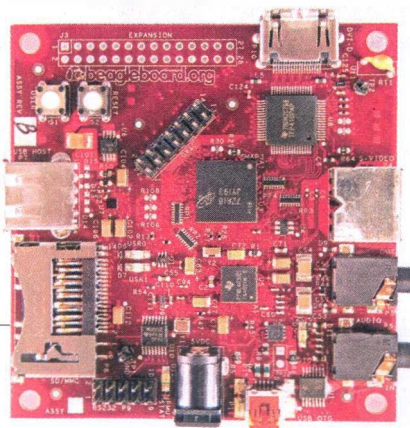
Nanoelectronics is based on the application of nanotechnology in the field of electronic components.

Conventional computers with big processors will be replaced with nanocomputers with nanoprocessors that will have higher performance and speed than the conventional computers.

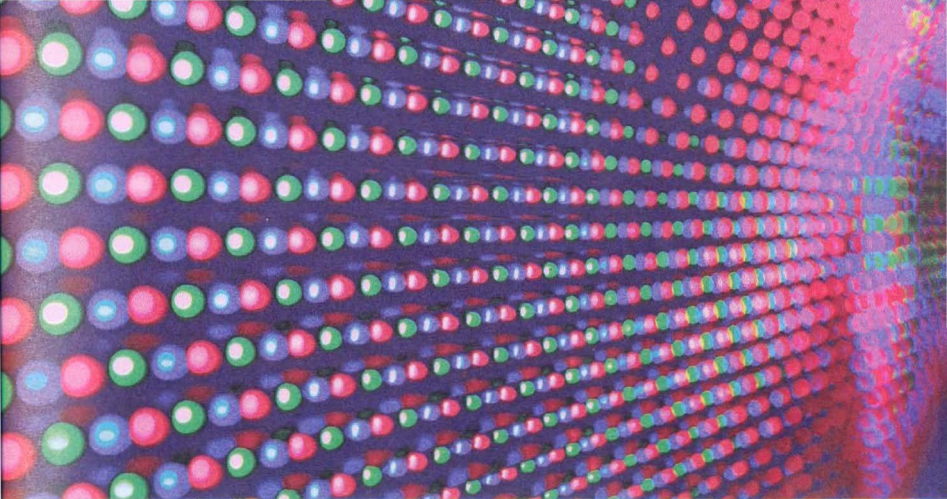
The devices using nanoelectronics technology also include solar cells that are highly efficient, and cheaper than the conventional ones.

If such efficient solar energy can be created, it would be a revolution for global energy needs. Televisions, LEDs, and computers will also be devices using nanoelectronics.

*Beagle Board  
Single board Computer  
(75mm)*







## LED

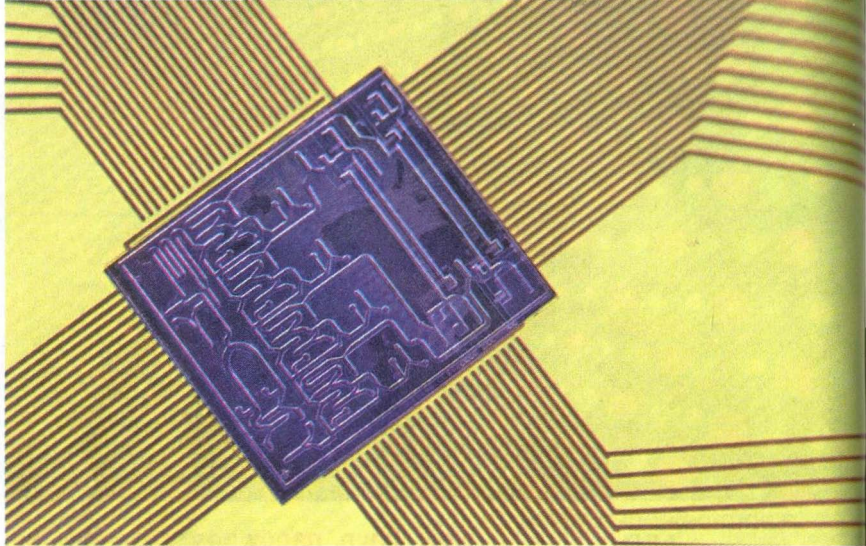
### How have nanowires changed the future of LED displays?

**N**anowires are structures with diameters in the range of tens of nanometres and lengths to the order of hundreds of nanometres to micrometres.

By comparison, the diameter of a human hair is about 500 times larger than a 100 nanometre nanowire. Each nanowire acts basically as an individual light-emitting diode or LED. Any colour of the visible spectrum, ranging from deep blue to red, can be realized using nanowire LEDs.

Therefore, nanowires make it possible to manufacture larger and more flexible LED displays, and nanotechnology might change the physical form of laptops, cell phones, and TV displays in the future.





## Why was the invention of the millipede chip so important?

*Millipede Chip*

---

**I**n nanotechnology, the term millipede refers to a new approach to storing data at high speed and ultrahigh density.

The interesting part is that millipede stores digital information in a completely different way from magnetic hard disks, optical disks, and transistor-based memory chips. It promises a data density of more than 1 terabit per square inch, and has some similarity with the punch card.

Millipede uses thousands of tiny sharp points—hence the name—to punch holes into a thin plastic film. Each of the 10-nanometre holes represents a single bit.

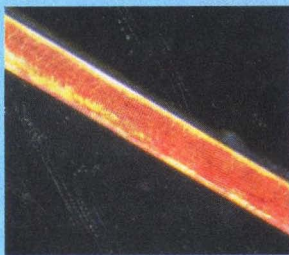
Millipede is rewritable, and it may eventually enable storage of over 1.5 GB of data in a space no larger than a single hole in the punch card.



## STAR FACT

### How Small!

Your fingernails grow at the rate of one nanometre per second. This is about  $1/25,000$  diameter of a human hair.



*Highly Magnified Strand of Human Hair*

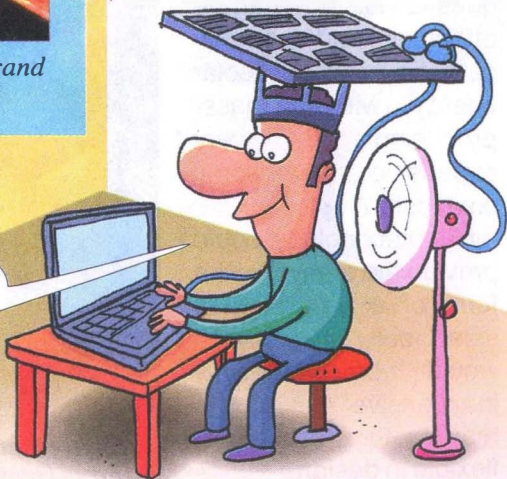
**How can nanotechnology help to meet the growing demand for fuel?**

Nanotechnology will bring significant benefits to the energy sector, especially to energy storage and solar energy.

Improved materials efficiency and reduced manufacturing costs are just two of the real economic benefits that nanotechnology already brings to these fields, and these are only the beginning.

Battery storage capacity could be extended, solar cells

I'm a Nano Man.





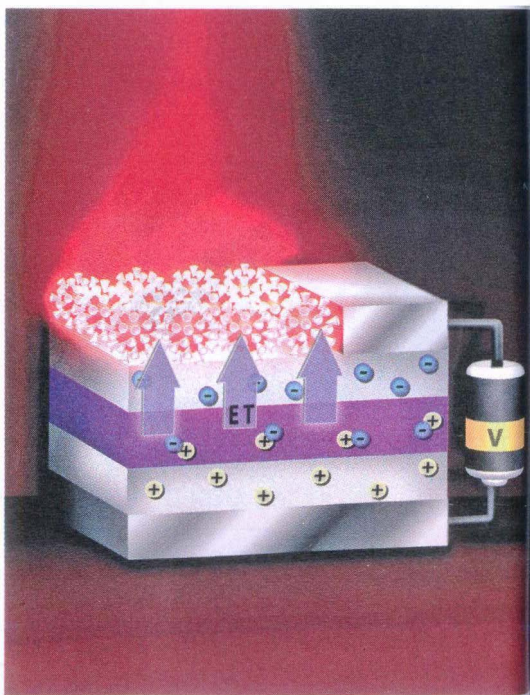
could be produced cheaper, and the lifetime of solar cells or batteries for electric cars could be increased, all thanks to continued development of nanotechnology.

We must remember that there's only one source of renewable energy that can provide all of the world's needs, and that is the Sun. In fact, enough sunlight falls on the Earth's surface in just a couple of hours each day to meet the whole world's energy needs for one year. The question is...how can we effectively and economically harness this solar energy, without mass-producing very expensive conventional solar cells?

Nanotechnology could provide the answer in the form of a new kind of solar cell, one which would be relatively inexpensive to manufacture, and highly flexible in design.

## What is the importance of quantum dot laser?

A laser is a machine that gives a strong single-colour source of light. It uses special gases or crystals to make light with a single colour. Then, mirrors are used to amplify that colour of light, and to make all the light travel in one direction.



*Device that Produces Visible Light From Quantum Layers to Crystals*



As a result, the light stays as a narrow beam, and when pointed at something, this narrow beam makes a single point of light. All of the energy of the light stays in that one narrow beam, instead of spreading out like a flashlight.

Quantum dots are tiny nanocrystals that glow when stimulated by an external source, such as ultraviolet light. How many atoms are included in the quantum dot determines their size, and the size of the quantum dot determines the colour of light emitted.

Lasers made of quantum dots are known as quantum dot lasers. The diameter of the dot determines the wavelength of the light emitted. The advantage of quantum dot lasers is that they are cheaper than conventional lasers, and the beam of light is of better quality.

### *Quantum Dots Emissions From Violet to Red*

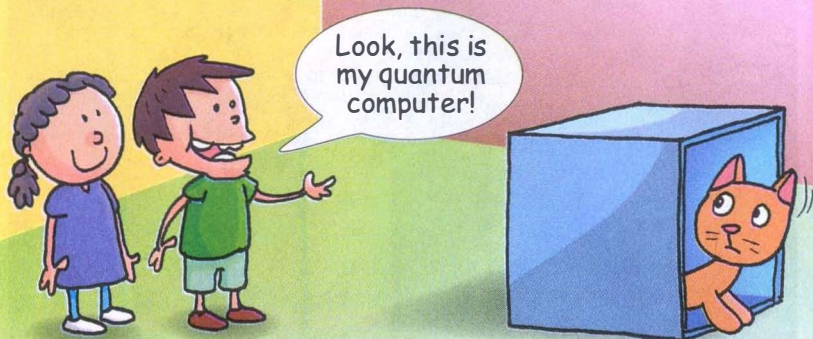
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## STAR FACT

### Pioneers

**Yuri Manin and Richard Feynman** are the pioneers in the field of quantum computing. Their contributions were made in 1980 and 1982 respectively.



## What is a quantum computer?

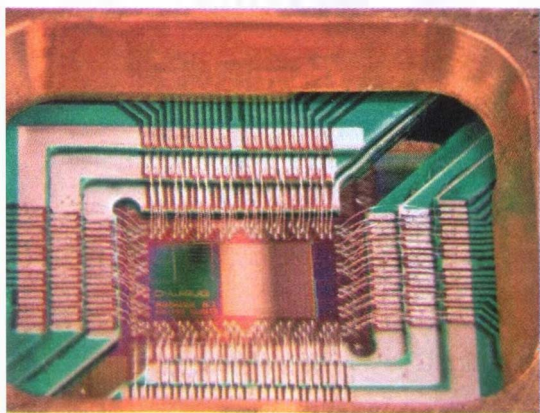
**Q**uantum computers are computers that harness the power of atoms and molecules to perform memory and processing tasks.

Quantum computers are different from digital computers that are based on transistors. Whereas digital computers require data to be encoded

into binary digits or bits, quantum computation uses qubits or quantum bits.

Quantum computers will be able to perform calculations faster, and on a far greater order of magnitude, than traditional computers.

Quantum computers have been built on a small scale, and work continues to upgrade them to more practical models. A handful of quantum computers have been built so far, and research in this field is still going on.



*A Chip used in  
Quantum Computers*





*A High Temperature Superconductor Levitating  
above a Magnet*

### **How is nanotechnology helpful in achieving superconductivity?**

**C**ertain materials- mainly, metals or ceramics- show a complete absence of electrical resistance at low temperatures, and this phenomenon is known as superconductivity.

If you send a current through a superconducting wire, it loses no energy to resistance. However, superconductors require very cold temperatures. This is where nanotechnology can help.

The unusual size and shape of the carbon nanotubes have been found useful in making them superconductive at relatively high temperature. It has been shown that these carbon nanotubes can conduct electricity without any resistance, at temperatures stretching up past the boiling point of water.

The tubes would be the first superconductors to work at room temperature, and this is a giant stride forward in the field of superconductivity.



## What is 'smart dust' in nanotechnology?

**S**mart dust is a concept that originated in the 1990s as a result of a research project of the US Defence.

Smart dust is made of 'motes' that are tiny sensors which can provide a variety of functions. These sensors are actually MEMS or microelectromechanical systems.

Though these motes are so tiny, they still contain a battery, a wireless transistor, and some amount of RAM; in short, a microscopic operating system that allows the whole thing to run.

The practical applications of smart dust can be applied to any industry- for monitoring crops, or the output of machines, or to track animal migration patterns, wind and humidity, and even to monitor your bodily functions!



## CURIOUS FACT

### Blackout

A science fiction show on TV shows how nanotechnology can be misused to cause a worldwide blackout. It is named 'Revolution' and is aired on the NBC TV channel in the USA.

## What is the importance of nanorobotics?

**A** nanorobot is a microscopic robot built with nanotechnology. These robots will be able to sense and adapt to external factors such as heat and light. They can be used for everything from repairing space satellites, to killing blood-borne pathogens and cancers.

Nanorobotics is the technology of creating machines or robots at, or close to, the scale of a nanometer.

For example, in the future, if you have a fever, your doctor will be able to place a tiny robot into your bloodstream. The robot detects the cause of your fever, travels to the appropriate system, and provides a dose of medication directly to the infected area.

---

*Nanorobot*





## How are nanorobots useful in medicine?

**N**anorobots are so small that they actually interact on the same level as bacteria and viruses do.

It is anticipated that they could be equipped with all sorts of tools and cameras in order to furnish more extensive information about the human body. Not only that, they can perform millions of useful tasks.

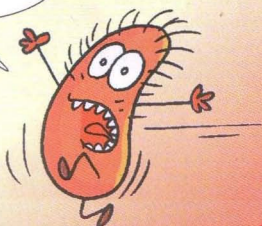
Among these is the ability to float neutrally through your bloodstream, identifying problem areas of your body, and fixing them.

Nanorobots could be used to clear built-up cholesterol from your arteries, thereby saving you from a heart attack. When it comes to major diseases like cancer, nanorobots are perfect for eradicating malignant cells.



*Nanorobot - Magnified  
Illustration*

Help me!  
Nano turns  
viral!



# nanotechnology & MEDICINE

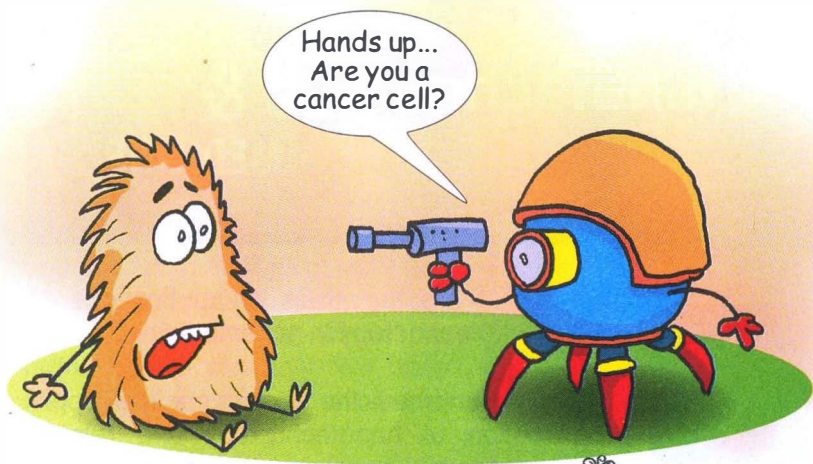


## What are the areas of applications of nanotechnology in nanomedicine?

**N**anomedicine is the medical application of nanotechnology and related research.

Applied to medicine, nanorobots would be programmed for specific biological tasks, and injected into the blood in a solution to work on cancer cells, on viruses, and even for reversing the aging process.

Established and near-future nanomedicine applications include activity monitors, chemotherapy, pacemakers, biochips, insulin pumps, needleless injectors, hearing aids, medical flow sensors, and blood pressure, glucose monitoring and drug delivery systems.



## Why is nanotechnology a boon in cancer treatment?

**T**he use of nanotechnology in cancer treatment offers some exciting possibilities. Usually, we depend on surgery, chemotherapy, or radiation treatment to destroy cancer. Unfortunately, these treatments can carry serious side effects. With nanotechnology, targeted drug therapies are possible. If scientists can load their cancer-detecting nanoparticles with anticancer drugs, they could attack the cancer cells exactly where they are located.

Nanotechnology, therefore, opens the doors to the possibility of destroying cancer tumors with minimal damage to healthy tissue and organs.

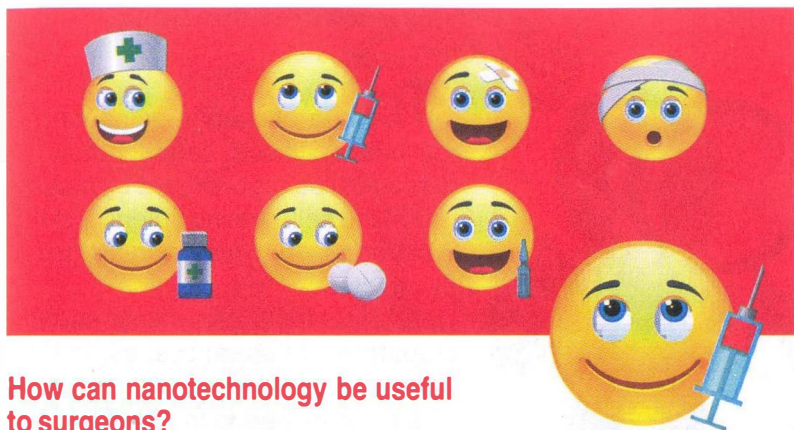


## AMAZING

### Gold at the Nanoscale

Gold at the nanoscale has different properties from the gold that we know. Nano gold particles are not the yellow colour with which we are familiar with, but can appear red or purple in colour.





## How can nanotechnology be useful to surgeons?

The role of nanotechnology in surgery is evident in the miniaturization of surgical tools. Experimental microrobots are already available, and being tested in live tissues.

In the US, Rice University has made a significant invention named 'flesh welding'. Flesh welding is a new technology which can replace the old clumsy and infection prone stitching method after the surgery.

An experiment was conducted on two chicken pieces which were placed together, touching each other. A liquid containing gold-coated nanoshells was dribbled along the seam. An infrared laser was traced along the seam, causing the two sides to weld together. This technique is known as 'flesh welding'.



## STAR FACT

### Nano Coatings

Nanotechnology can provide us with innovative coatings that have scratch resistance, fire proofing, light transmission, heat resistance, and dirt shedding properties. These coatings will be very useful on vehicle surfaces.



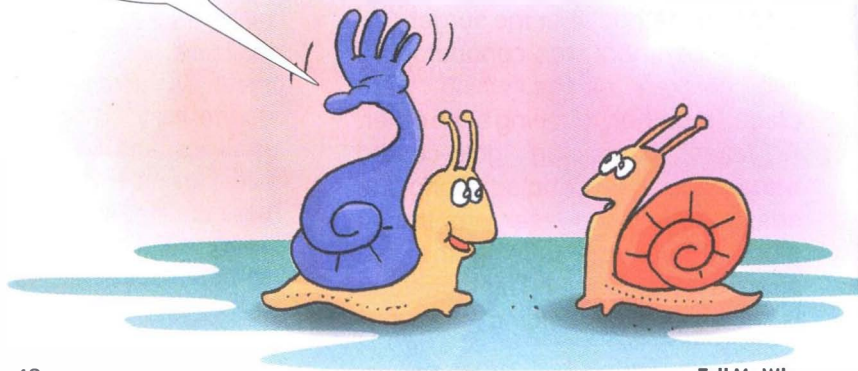
## Why is nanotechnology important in tissue engineering?

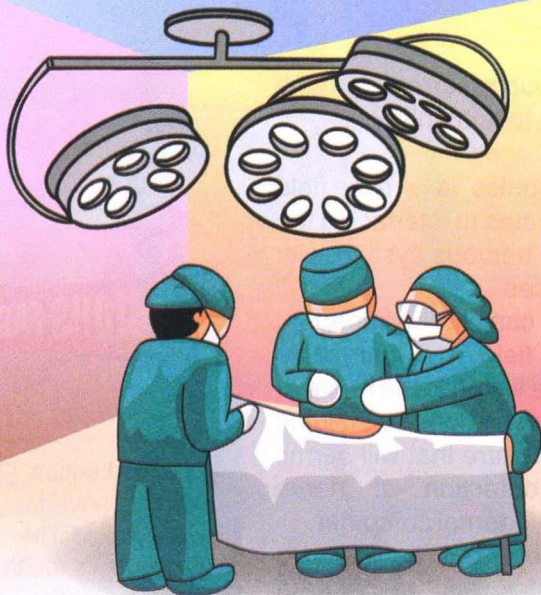
The idea of tissue engineering is to induce tissue regeneration of damaged tissues or organs by making use of the self-healing potential of the living body, or by providing biological substitutes.

Nanomaterials can mimic surface properties of natural tissues. In fact, the unique properties of nanomaterials have helped to improve various tissue growth.

Research has also shown that bones could be regrown on carbon nanotube scaffolds. There is every possibility, therefore, that in time, tissue engineering using nanotechnology will replace the organ transplants and artificial implants of today. In India the Sri Chitra Institute of Science and Technology, Trivandrum does considerable research on this topic.

Earlier,  
I was at a tissue  
engineer's lab as  
an assistant.





## How is nanotechnology used in arthroscopes?



**AMAZING**

### Nanosponges

Scientists are trying to develop 'nanosponges' that can absorb toxins, and remove them from the bloodstream.

**A**rthroscopes are pencil-sized devices that are used in surgeries. They have lights and cameras that enable surgeons to do surgeries with smaller incisions.

Nanotechnology is helping to advance the use of arthroscopes, by making them smaller and smaller.

In fact, arthroscopes will hopefully, become smaller than a strand of hair in the future, with the help of this technology. Such tiny arthroscopes would mean even smaller incisions, which in turn, would promote faster healing.



## Why are neuroelectronic nano devices a boon to humanity?

**N**euroelectronics is a new field that broadly relates to interfacing the neurons of the nervous system with electronic devices.

Nanodevices can play an important role in this field by permitting computers to be linked to the nervous system. This can be done by building a molecular structure that will permit control and detection of nerve impulses by an external computer.

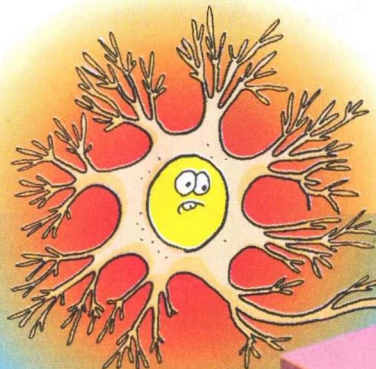
The computers will be able to interpret, register, and respond to signals the body gives off when it feels sensations. Many diseases today involve the decay of the nervous system, and so, the demand for such devices would be great.



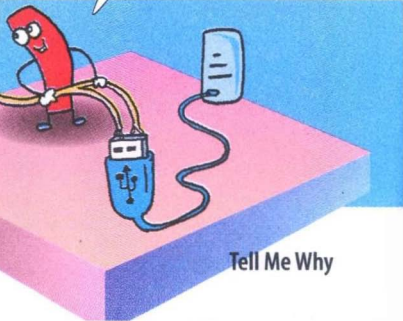
### CURIOUS FACT

#### Novel Nano

**Robert Ludlum** wrote a novel in 2005 called 'The Lazarus Vendetta.' Its theme is the ability of nanotechnology to cure cancer.



Just a shock treatment.





### What are the limitations of neuroelectronic nanodevices?

**N**euroelectronic nanodevices have many advantages, but there are many limitations, too.

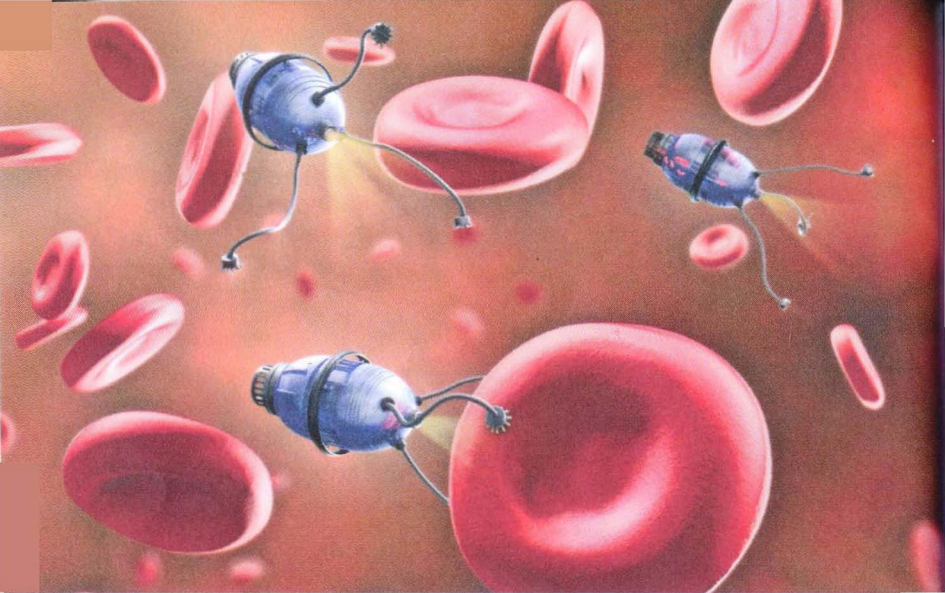
To begin with, electrical fields and electromagnetic pulses can interfere with their working. Very thick insulation is needed to prevent electrons from leaking, and very thick wires are needed to prevent overheating. The wiring for these devices is complicated, and huge technical and research inputs are needed to make them. As a result, they are extremely expensive.



### STAR FACT

#### White Light

Clusters of silver nanoparticles naturally emit white light. They can be shaped into a sort of nanomirror, and placed under a specimen in a microscope. They are very useful in studying both the outer, and the inner structure of a specimen.



## What is nanonephrology?

**N**anonephrology is a branch of nanomedicine and nanotechnology. It uses nanomaterials and nanodevices for the diagnosis, therapy, and management of diseases of the kidney.

This branch of nanomedicine deals with the study of kidney protein structures at the atomic level, as well as nano-imaging approaches to study cellular processes in kidney cells. It also deals with nanomedical treatments that utilize nanoparticles to treat various kidney diseases.

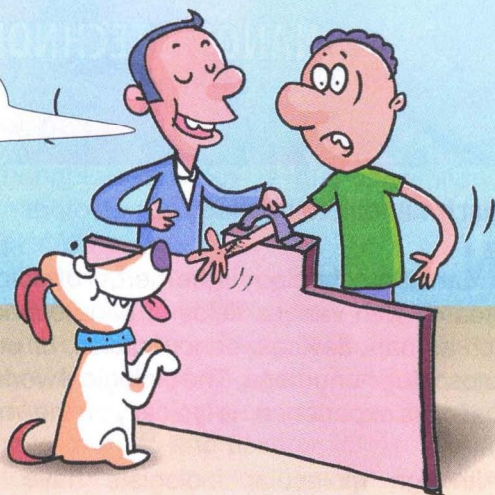
In the future, it may include nanorobots to treat kidney diseases, and the manufacture of nanoscale artificial kidneys, but for the present, these goals still remain a dream.

*Nanorobots in  
Blood stream*

---



This machine  
will repair your  
damaged cells...



## What are cell repair machines?

Our body's cells and organisms already perform extremely complex feats of repairing damaged cells and tissues naturally.

They do this by using a variety of molecular machines - machines constructed to molecular specifications- that nature has already placed in the body.

Nanotechnology will allow us to build any of these molecular machines, and to assemble

them in ways not seen in nature.

Among these objectives will be sophisticated cell repair. These nanomachines will be able to enter cells, sense differences from healthy ones, and make modifications to the structure. They will be controlled by nanocomputers that will direct the machines to examine, take apart, and rebuild damaged molecular structures.

Working cell by cell, and tissue by tissue, whole organs can be repaired in this way!

# NANOBIOTECHNOLOGY

## What is nanobiotechnology?

**N**anobiotechnology is the merger of biological research with various fields of nanotechnology such as nanodevices, nanoparticles, or unique nanoscale phenomena. The biological world that most of us experience, is typically on the 'macro' scale.

Although molecular biologists have been working with nano-sized biomolecules for the last few decades, nanobiotechnology was not defined as a discipline until researchers started making a focused effort to use our knowledge of nanotechnology to tackle biological problems.

Goodbye...  
see you as a nano  
particle...



## What are the major objectives of nanobiotechnology?

The most important objective of nanobiotechnology is the application of nanotools to medical and biological problems.

Another primary objective is to develop new tools for this field. New nanotools are often made by refining the nanotools that are already being used. The imaging of native biomolecules, biological membranes, and tissues, is also a major topic for the nanobiology researchers.

Many research centres are also involved in the development of nano-biochips, nano-biosensors, and nano-biomaterials. In fact, biologically-inspired nanotechnology uses biological systems as the inspiration for technologies not yet created.



**AMAZING**

### Spider Silk

Scientists today are using nanotech-

nology to try and make synthetic spider silk, because spider silk is super strong and stretchy. Though it looks fragile, spider silk is tougher than bone and steel!

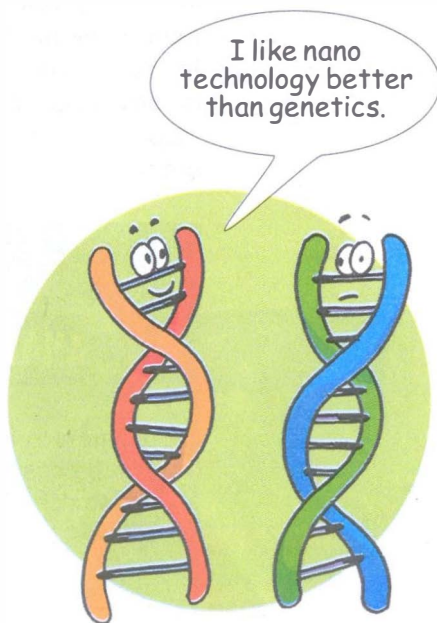




## Which are the branches of science that come together in nanobiotechnology?

**N**anobiotechnology sees several branches of science coming together. Most of the fundamentals of nanobiotechnology, as well as its devices, come from nanotechnology.

However, photonics, chemistry, biology, biophysics, nano-medicine, and engineering also play an important role in this exciting new branch of nanotechnology. Genetics and computer science also have a role to play in nanobiotechnology.





## How has nanobiotechnology proved useful in medicine?

**N**anobiotechnology has great potential for advancing medical science, thereby improving health care practices around the world. It has proved of immense value in many cases, from treating symptoms to generating cures, and regenerating tissue.

Nanobiotechnology techniques have helped three American patients who have received whole cultured bladders as a result of advances in this field. Research has also shown that it may be possible one day to grow a uterus outside the body!

The future may also see new limbs being grown so that people who lose an arm or leg need not have to make do with artificial limbs. The possibilities are mind boggling, and nanobiotechnology holds the key to translating them into reality.



### STAR FACT

#### Dendrimer

A dendrimer - from Greek dendra for tree- is an artificially manufac-

tured or synthesized molecule, that is built up from branched units called monomers. Dendrimers are of interest to researchers in medical technology, where they might help carry and deliver drugs in the body.



### What are the major tools in nanobiotechnology?

Nanobiotechnology relies on a variety of research methods, including experimental tools. It combines the tools, ideas, and materials of nanoscience and biology, and attempts to build molecular machines utilizing concepts seen in nature.

Experimental tools like imaging and X-ray diffraction based tools and self-assembly tools all play a role in this field, and will help in discovering new ways of detecting disease, supporting regenerative medicine, and improving the efficiency of drug delivery.

**“** *All the written words of history could fit on a cube of material measuring just one-hundredth of an inch wide, if the words were written with atoms.* **”**

**- Richard Feynman**



# GREEN nanotechnology

## Why is green nanotechnology important?

**G**reen nanotechnology is the study of how nanotechnology can benefit the environment, such as by using less energy during the manufacturing process, the ability to recycle products after use, and using eco-friendly materials.

It builds on the principles of green chemistry and green engineering, and focuses them through a new lens on the unique effects that occur in nanoscale materials.

Green nanotechnology can help us provide clean water to billions of people via novel filtration techniques, and has the ability to decontaminate dirty water. It can increase the use of renewable energy; and help in waste management too. In fact, renewable energy applications probably are the areas where nanotechnology will make its first





## STAR FACT

### DNA Nanotechnology

DNA nanotechnology deals with the design and manufacture of artificial nucleic acid structures for technological uses. The concept was first put forward by Nadrian Seeman in the early 1980s, and the field began to attract widespread interest in the early 2000s.

large-scale commercial breakthroughs.

Green nanotechnology can also influence the design of nanomaterials and products by eliminating or minimizing pollution from the production of these materials. Green nanotechnology will, hopefully, help us replace existing products with new nano-products that are more environmentally friendly throughout their life cycle.

Enjoying  
the taste of green  
nanotechnology.



### What are the goals of green nanotechnology?

**G**reen nanotechnology is about doing things right in the first place about making green nano-products, and using nano-products in support of sustainability.

Sustainability is a term used to denote development that meets the needs of the present, without compro-

mising the ability of future generations to meet their own needs.

The first goal of green nanotechnology is to produce nanomaterials and products without harming the environment or human health.

The second goal is to produce nano-products that provide solutions to environmental problems. Green nanotechnology achieves these goals by using the existing principles of green chemistry and green engineering to make nanomaterials and nano-products that are eco-friendly.



## CURIOUS FACT



### Silver Dollar

The United States silver dollar has a surface area of about 27.70 square centimetres. If it were to be divided into tiny particles one nanometre in diameter, the total surface area of those particles would be 4 million times greater than its present surface area.





# nanotechnology & INDUSTRY

## Why will nanotechnology usher in a new industrial revolution?

Nanotechnology will make it possible to manufacture more and better consumer goods, like clothes that are not just wrinkle free and stain repellant, but also smart because they will have tiny electronic devices embedded in them.

Similarly, car bumpers will become lighter, sunscreen will be more radiation resistant, synthetic bones will become stronger, packaging will have a longer shelf-life, balls for various sports will be made more durable. The list is long and exciting.

All this will lead to an ever greater demand for consumer goods... which in turn, will usher in another industrial revolution.



## Why do nano products have a great future in the food industry?

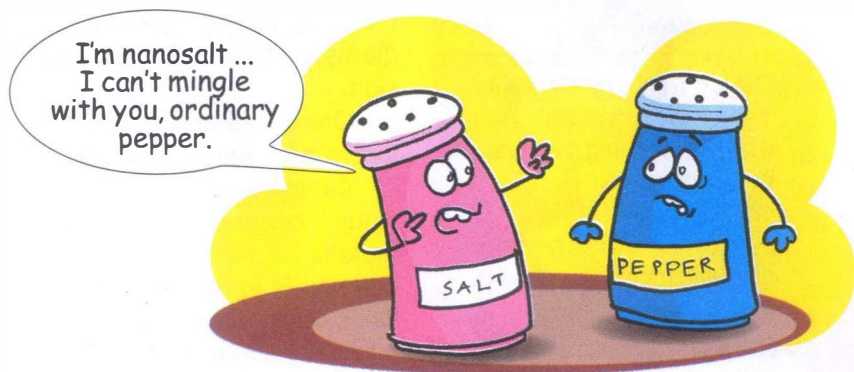
**N**anoproducts can give a boost to the food industry at several levels.

Nano-engineered materials can minimize carbon dioxide leakage out of carbonated beverages, or reduce oxygen inflow, moisture outflow, or the growth of bacteria in order to keep food fresher and safer, longer.

Nanosensors built into plastic packaging can warn against spoiled food too.

Carving up a grain of salt into these smaller particles increases its surface area a million-fold, which means that your food needs far less salt to give your taste buds the same savoury kick.

In short, nanoproducts can offer so much to the food industry, and even the promise of a technological solution to the problem of the one billion people who don't get enough to eat.



## How can nanotechnology be helpful to housewives?

**N**anotechnology can be a boon to housewives too. The most common use of nanotechnology in the household is cleaning products.

The tiny nanoparticles in cleaning products allow you to be able to clean off things like dirt and food remains, in a simple but effective way.

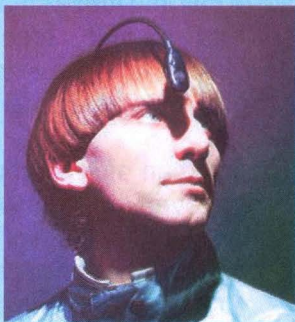
Nanoceramic particles have improved the heat resistance and smoothness, which make them very useful in many household appliances.

Housewives will also find exciting new cosmetic products. Cosmetics giant L'Oreal, for example, says it has developed a nanocapsule that delivers active ingredients, deep into the layers of skin.

L'Oreal and other manufacturers also use nanoparticles of titanium dioxide and zinc oxide to create vivid and metallic shades of lipstick and eye shadow. Similar nanoparticles are used in several brands of sunscreen.



### STAR FACT



#### Cyborg

The term 'cyborg' stands for 'cybernetic organism' which is anything that has both organic and mechanical parts. Right now, it refers to people who have electrical implants in their bodies.




## Why is nanotechnology important to the textile industry?

Today, we already have clothes that are wrinkle free and stain repellant. Nanotechnology offers the textile industry many other advantages as well.

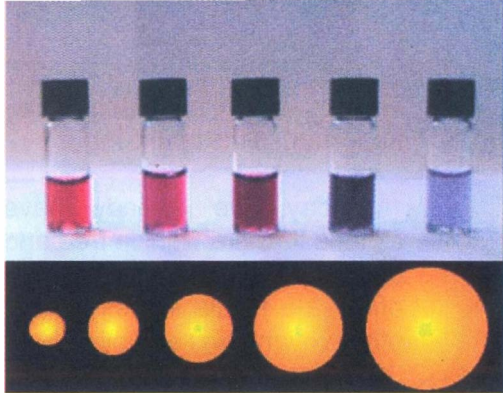
Textiles with a nanotechnological finish can be washed less frequently, and at lower temperatures. More glamorous applications include embedding gold nanoparticles into natural fabrics such as wool.

The gold nanoparticles impart soft colours from pale soft greens, to browns and beiges, depending on the particle size and shape. These colours are stable, and may even provide some antibacterial properties to the fabrics, as an added bonus!

Already on the market are socks and leisurewear with embedded silver nanoparticles that combat odour through killing bacteria. Scientists are also working on nanoelectronic devices that can be embedded into textiles to provide special support systems for individuals in dangerous professions or sports.



Don't worry!  
I'm safe in this  
nano suit.



*Solution of Gold Nanoparticles*

## What are the uses of nanotechnology in the cosmetic industry?

**T**he cosmetic industry has discovered that nanotechnology can help it in making better and safer products.

In the cosmetic arena, it is believed that the smaller particles are more readily absorbed into the skin.

One such example is the use of nanotechnology in sunscreens. Sunscreens regularly contain titanium dioxide and zinc oxide nanoparticles due to their ability to absorb ultraviolet radiation. Nanoparticles, which have antibacterial activity, are also being used as preservatives.

Gold nanoparticles in facepacks are believed to have anti-inflammatory and antioxidant properties. It is also believed that as new products are developed, nanotechnology may be used to prevent graying hair, and combat hair loss in some cases.



## CURIOUS FACT

### Grey Goo

The term 'grey goo' refers to a disaster scenario caused by nanotechnology. In this scenario, out-of-control self-replicating robots consume all matter on Earth while building more of them. The term was coined by nanotechnology pioneer Eric Drexler in his book 'Engines of Creation' (1986).



## What is the role of nanotechnology in sports?

**T**he world of competitive sports is highly influenced by even minute changes in sports equipment, which could be a matter of winning or losing... and this is where nanotechnology can be of help.

Within the niche of sports equipment, nanotechnology offers a number of advantages and immense potential to improve sporting equipments making athletes safer, more comfortable and more agile than ever.

Baseball bats, tennis and badminton racquets, hockey sticks, racing bicycles, golf balls and clubs, skis, fly-fishing rods and archery arrows are some of the sporting equipments, whose performance and durability are being improved with the help of nanotechnology.







### **Why is nanotechnology a boon to aerospace and vehicle manufacturing industries?**

**T**he aerospace industry is one of the most important heavy industries in the world, and nanotechnology will play an important role in its future.

The main goal in current aerospace industry is the invention of lighter construction materials, and more efficient engines.

Various nanomaterials have been used in aircraft construction, and these include nanoclays, carbon nanotubes, nanofibres, and graphene.

Nanotechnology promises to benefit many aspects of the vehicle industry. For several years, nanotechnology research has been working towards coatings and paints which are highly scratch resistant, self-healing, and dirt repellant. These technologies would allow automotive paint to last for the lifetime of the vehicle without aging, and require cleaning much less often.

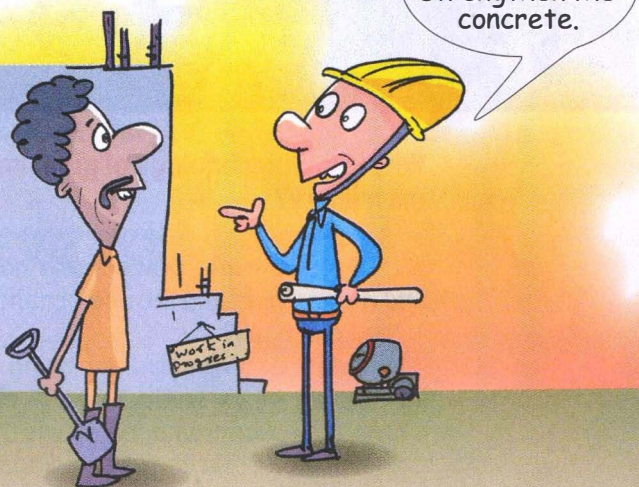
## What is the role of nanotechnology in the construction industry?

**N**anotechnology can make construction faster, cheaper and more efficient.

Two nanoparticles that stand out in their application to construction materials are titanium dioxide, and carbon nanotubes. The former is being used for its ability to break down dirt, and then allow it to be washed off by rain water on everything from concrete to glass, and the latter is being used to strengthen and monitor concrete.

A number of companies are using nanotechnology to add special characteristics to product surfaces, which can be anything from stain-resistance and colour durability to self-cleaning, improved hardness, and scratch-resistance.

From making concrete and glass that's fire-protective, to giving strength to wood and steel at much lower densities, nanotechnology is helping us build a safer, cleaner, and more efficient world.



# nanotechnology & MILITARY



## Why is nanotechnology of great importance to the military?

**A**ll major world powers are now investing and researching into the use of nanotechnology in the field of military.

Nanofabrics are currently being researched for use in military camouflage. A development called 'active camouflage,' allows the wearer or object to blend into its surroundings.



Nanoparticles can be injected into the material on soldiers' uniforms to not only make the material more durable, but also to protect soldiers from many different dangers such as high temperatures, and impact of chemicals.

Another important use for nanotechnology is for manufacturing sensors. Portable, efficient sensors will be highly valuable to military field operatives.

## How is nanotechnology useful in the battlefield?

**N**anotechnology can improve medical and casualty care for soldiers. It can produce lightweight, strong and multi-functional materials for use in clothing, both for protection and to provide enhanced connectivity. Improved body armour is a major focus for military nanotechnology research. Nanotechnology will also provide soldiers with armour that is a hundred times stronger, and six times lighter than steel. Nanotechnology also can provide





self-changing camouflage. This is done by injecting mobile pigment nanoparticles into the uniform material. These mobile pigment particles would be able to change the colour of the uniforms, depending upon the area that the soldiers are in, to provide effective camouflage.

In addition, nanotechnology can help to lower the infrared signature of both the soldiers and the military vehicles. This will provide better protection from infrared guided weapons, or infrared surveillance sensors. On another front, nanotechnology will lead to lighter and stronger materials with different properties, which will mean a major transformation of weapons used on the battlefield.



## STAR FACT

### All in One

**Nanotechnology is a meeting place for all the different branches of science, including physics, chemistry, and biology. It creates a scientific world without boundaries.**

## How can nanotechnology help in military communication?



The discovery of several new nanotechnology advancements has made military communication very sophisticated.

Nanoparticles can be used to create coated polymer threads that can be woven into soldiers' uniforms. These polymer threads can be used as a means of communication between soldiers on the move. The threads in the uniforms can be set to different wavelengths, to eliminate the possibility of anyone else listening in.

The discovery of new nanotechnology advancements that can be integrated into current wireless devices and systems will enhance the capabilities of soldiers in the field even further.





**How can medical surveillance using nanotechnology help the armed forces?**

**N**anotechnology can help to put in place a medical surveillance system for soldiers. Soldiers can wear this system which would watch over their health and stress levels, and release drugs, or treat wounds, as the need arises.

This system will administer painkillers in the case of trauma or injury, and will be able to inform doctors about the soldier's health status at all times.

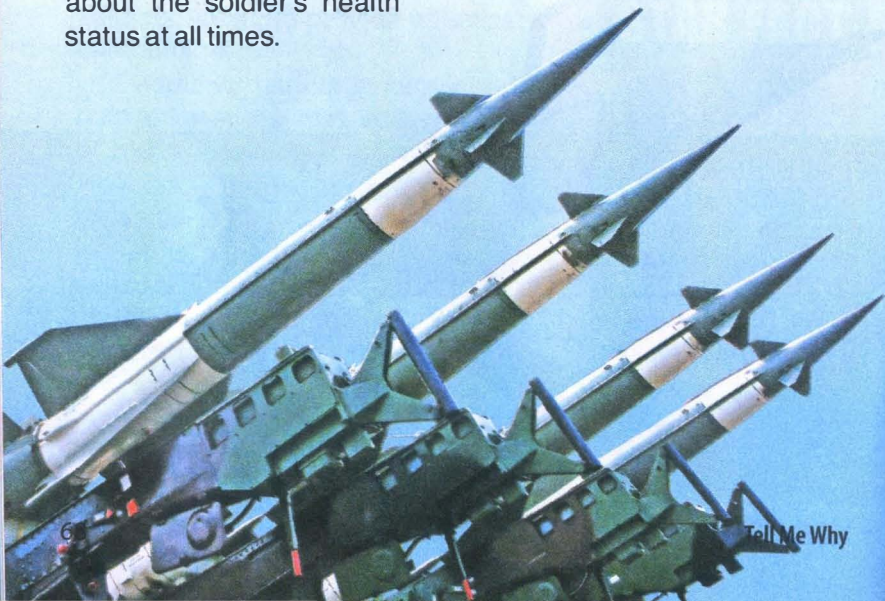


## STAR FACT

### Nanoweapons

Nanotechnology will also be useful in creating new weapons. These weapons, which are still in the experimental stage, are called nanoweapons.

● *Sneha Rao*



# nanotechnology & AGRICULTURE

## How is nanotechnology important in agriculture?

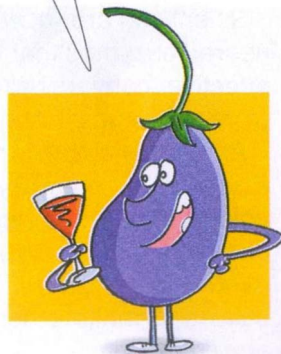
The science of nanotechnology has a great future in the field of agriculture. This sector will benefit greatly from nanotech-based tools to detect diseases in a rapid manner, improve the ability of plants to absorb nutrients, and promote the molecular treatment of diseases.

The implementation of nanotechnology in the form of small sensors and monitoring devices will create a positive impact in farming methods.

Nanoparticles can serve as 'magic bullets', containing herbicides, chemicals, or genes, which target particular plant parts to release their content.

Farmers can make excellent use of nanotech-enabled 'smart' devices that can perform two roles- that of being a preventive, as well as an early warning system. These devices can identify plant related health issues even before they become visible to the farmers, and simultaneously, provide remedial measures.

This  
nanotonic makes  
me strong.





## How can nanotechnology recycle agricultural waste?

**N**anotechnology can help reduce agricultural waste and bring down pollution levels. For example, when cotton is processed, some of the fibres are discarded as waste, or used for low-value products such as cotton balls, yarns, and cotton batting. This waste can be transformed by nanotechnology into nanofibres that can be used as a fertilizer, or pesticide absorbent.

Scientists are now working on nano-engineered enzymes that will allow simple and cost-effective conversion of cellulose from waste plant parts into ethanol.

Another example is rice husk that can become a source of renewable energy with nanotechnology. When rice husk is burned into thermal energy or biofuel, a large amount of high quality nano-silica is produced, which can be further utilized to make other materials such as glass and concrete.

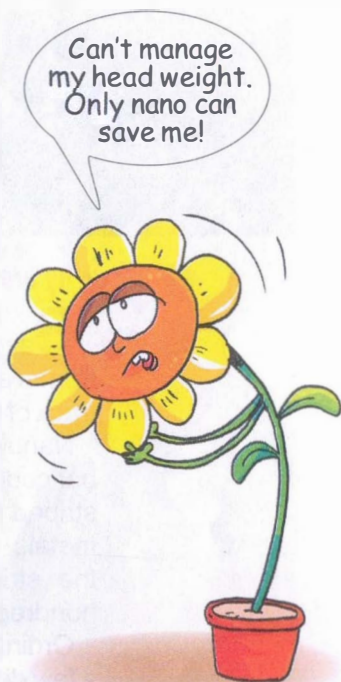


## How can nanotechnology increase agricultural growth?

The use of nanomaterials in agriculture can reduce cost and effort, increase efficiency, and lead to a better environment.

Nanomaterials are becoming an increasingly important issue in agriculture, particularly as additives or agents in fertilizers, or plant protection products. In the case of pests or drought, nanotechnology makes it possible for an automatic adjustment of pesticide or irrigation levels, to counter these challenges.

Nanosensors dispersed in the field can also detect the presence of plant viruses, and the level of soil nutrients. Slow release fertilizers in nanocapsules can reduce both fertilizer consumption and environmental pollution.





### Why are nanobarcodes important?

**B**ar codes have revolutionized how everyone from warehouse managers to pharmacists keep track of items.

Nanobarcodes work much like conventional bar codes, except that they are microscopic rods, striped with bands of gold, silver, and other metals. Varying the width, number, and order of the stripes could generate thousands, if not hundreds of thousands, of unique identifiers.

Ordinary barcodes only let researchers analyze a few different types of molecules at a time.



With nanobarcodes, though, thousands of different tags could be added to a sample at once. Scientists at Cornell University have produced microscopic probes or nanobarcodes that could tag multiple pathogens in a farm which can easily be detected, using any fluorescent-based equipment.

In the future, nanobarcodes will help researchers identify patterns of perhaps hundreds of molecules that form molecular signatures for different diseases, and for different stages of illness and recovery.

---

*Cornell University*



## CURIOUS FACT

### Dry and Wet

**Dry nanotechnology uses inorganic materials including metals and semi-conductors on a nanoscale. Wet nanotechnology uses nanoscale materials on a biological level. Wet nanotechnology requires the presence of water.**





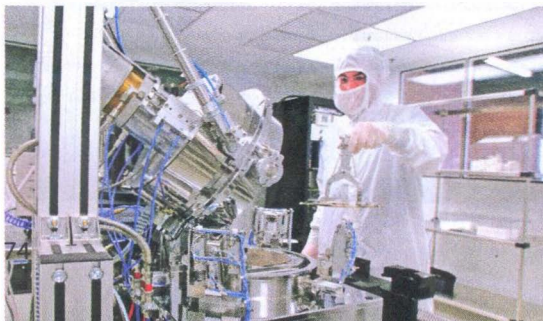
# nanotechnology & ENERGY

## What is nanofabrication?

**N**anofabrication technology, also known as molecular manufacturing, cuts across many technological systems and industries, including microelectronic chip manufacturing, power semiconductors, micro-electromechanical devices, information storage, computer displays, optoelectronics, pharmaceuticals, sensors, and biomedicine.

It is the process of designing and creating devices on the nanoscale, and it can play an important role in the development of new ways to capture, store, and transfer energy.

In fact, nanotechnology has been a key player in exploring new ways for producing energy, and the processing of fuels like carbon, gasoline, petroleum, solar energy, and aircraft fuel.



*Research on  
Nanofabrication  
in a Lab*

**Tell Me Why**

## Why is nanotechnology more energy efficient for use in LEDs?

**L**ight Emitting Diodes or LEDs, use much less energy than conventional lighting. An LED is a special kind of diode that glows when electricity passes through it.

Most LEDs are made from a semi-conducting material called gallium arsenide phosphide. The best part about LED lights is that they don't release any heat, unlike traditional bulbs. So also, LED lighting uses only a small percentage of energy as compared to regular bulbs, and they don't contain any toxic metals like mercury.

Today, scientists are researching the use of different nanotechnologies to create more energy efficient LEDs. Since LEDs manufactured with nanotechnology will also offer better picture quality, they will be used more and more in the display panels of appliances.



*LED Lights*



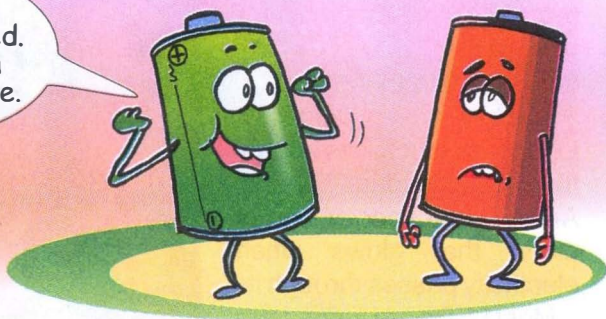
## STAR FACT

### Utility Fog

Nanotechnology is based on the concept of tiny, self-replicating robots. A collection of tiny robots that can replicate a physical structure is called a Utility Fog. The term was first used in 1993 by Dr. John Storrs Hall.

● *Radha Nair*

Dear, I'm  
nano powered.  
No one can  
discharge me.



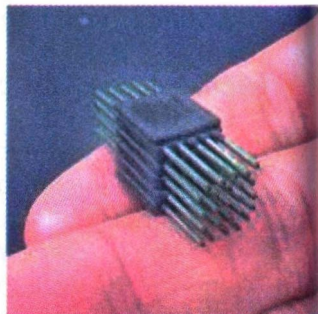
## What is the role of nanotechnology in the development of batteries?

**B**atteries are devices which store electrical energy by converting it into chemical energy, to be released slowly at a later time.

In rechargeable batteries, this chemical process is reversible, allowing the battery to be reused many times.

Nanotechnology can be utilized for the development of better batteries. It reduces the possibility of batteries catching fire by providing less flammable electrode material. It also increases the available power from a battery, and decreases the time required to recharge a battery. These benefits are achieved by coating the surface of an electrode with nanoparticles.

Nanotechnology also increases the shelf life of a battery. Researchers are predicting that the use of silicon can increase the capacity of batteries by ten times.



*Sugar Cube Sized  
Fuel cell*



*Solar Panel Films  
in which  
Nanoparticles are  
incorporated*

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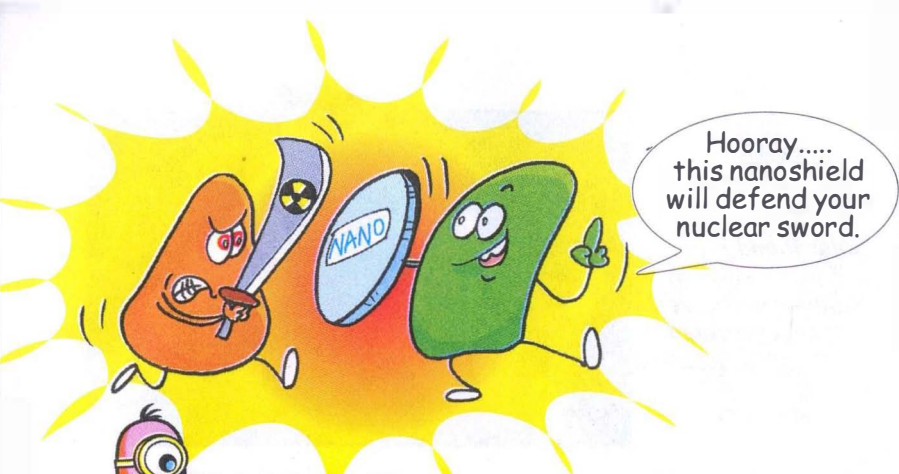
### **How can nanotechnology enhance the efficiency of solar energy production?**

**T**he power output of the sun that reaches the Earth could provide as much as 10,000 times more energy than the combined output of all the commercial power plants on the planet.

However, today's commercial solar cells, usually made of silicon, are still relatively expensive to produce.

Nanotechnology can reduce manufacturing costs for solar cells as a result of using a low temperature process. It can also reduce installation costs by producing flexible rolls instead of the rigid crystalline panels that are used now.

In short, nanotechnology may provide an answer to the efficiency problem, by tinkering with solar power cells at a fundamental level, to boost their ability to convert sunlight into power, and by freeing industry to use less expensive materials.



## STAR FACT

### Nanolithography

Lithography is a method of printing from a metal or stone surface. In this method, the areas to be printed are not raised as in usual printing, but made receptive to ink, while the other areas repel ink.

Nanolithography is concerned with the study and application of fabricating nanometre-scale structures.

### How can nanotechnology help in nuclear accident cleanup and waste storage?

The site of a nuclear accident poses many hazards to humans. Nanotechnology uses multirobot systems and nanomaterials in order to decontaminate nuclear accident sites.

Nanotechnology applications could also help to remove radioactive ions from the environment. A group of researchers from the Queensland University of Technology, Australia, have developed new nanomaterials for radioactive waste cleanups in water.

Developing efficient, and cost effective nanomaterials is of great significance to the nuclear industry, as well as the environment.



## CURIOUS FACT

### Fullerenes

Fullerenes are molecules composed entirely of carbon, in the form of a hollow sphere, ellipsoid, or tube. Fullerenes are highly stable chemically, and have a variety of unusual properties. The first fullerene was discovered in 1985 by Richard E. Smalley, Robert F. Curl Jr., and Harold W. Kroto.

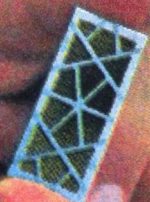
### What are the economic benefits of nanomaterials in the field of energy?

**F**uel cells that produce energy generally have a catalyst, usually platinum, which is very expensive. Using nanotechnology, catalysts can be designed through nanofabrication to provide efficient and cheaper options.

Carbon nanomaterials are also used in energy storage devices to improve energy storage capacity, provide faster recharge, provide lighter weight components, and offer longer cycle life.

The future of energy nanomaterials is full of innovative advancements that will revolutionize the energy industry, and have a great impact on environment and humanity.

*Nano Fuel Cell developed  
by Swedish Research  
Council*







## STAR FACT

### Breaking News!

The latest, from the ever growing world of nanotechnology - copper wire that can collect electricity! Jayan Thomas, an Indian-born Assistant Professor in Florida University, US, along with his student Zenan Yu, has developed a copper wire which can act both as a conductor, and a battery! The copper wire has brush type nanowires on its surface. This helps the wire to collect electricity, effectively. So, it's goodbye to batteries in electronic gadgets because the copper wire itself can replace batteries.



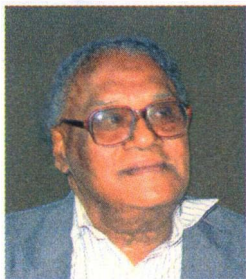
*Jayan Thomas*



## CURIOUS FACT

### Self - Heating Roads

Thanks to the work done by researchers at the University of Houston, USA, we will soon have self-heating roads. These roads will be embedded with sheets of carbon nanofibre that are warmed by an electrical element. This will be of great use in countries where severe winters make driving on icy roads dangerous.



*Prof. C.N.R. Rao*

### **What is the status of nanotechnology in India?**

**N**anotechnology is being hailed as the next sunrise industry for India. The Department of Science and Technology of the Central Government has announced a national initiative in nanomaterials, while the Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, has pioneered the study of nanotechnology in India. With the distinguished scientist Prof. C.N.R Rao at the helm, the centre has done world class research in nanotechnology using state of the art equipment.

A stream of nanotechnology-based products is beginning to emerge in India, with applications in the security realm. Besides DRDO (Defence Research & Development Organisation) serious researches are also taking place in institutions like IIT, and Madras University.

Nanotechie's  
Favourite  
Car...



### Which are the main agencies in India that are engaged in nanotechnology?

India has several key agencies in the field of nanotechnology, the chief of which is the Department of Science and Technology, also referred to as DST. India's principal programme in this area is the Nanoscience and Technology Mission which was allotted the sum of Rs 1000 crores for a period of five years. Around 200 projects have been undertaken by these agencies. In addition, Centres for Excellence for Nanoscience and Technology have also been established.

The Defence Research and Development Organization, the Council for Scientific and Industrial Research, and the Department of Biotechnology have all been supporting researches in nanoscience and technology.



# PROMINENT INDIAN SCIENTISTS IN nanotechnology

**Why is Dr. Meyyappan one of the leaders in the field of nanotechnology?**

**D**r. Meyyappan has been at the cutting edge of research in nanotechnology for many years.

An Indian by birth, he earned a bachelor's degree in technology and chemical engineering at the Regional Engineering College of Madras University in Trichy, India. Later, he moved to the USA. In 1996 he joined NASA, and is now the Director, Center for Nanotechnology in NASA.

His research covers the fields of carbon nanotube based nanotechnology, protein nanotubes, molecular electronics, quantum computing, and computational nanotechnology. He has authored, or co-authored, more than 175 articles.



*Dr. Meyyappan*

## Why is Dr. Minoo Dastoor considered one of the luminaries in this field?

**D**r. Minoo N. Dastoor was born in Mumbai, India. He immigrated to the US in 1962, and received an M.S. in Polymer Chemistry and a Ph.D. in Medical Microbiology and Immunology later.

Dr. Dastoor joined the Jet Propulsion Laboratory in 1977. In 1989, he assumed responsibility as a Manager for Environmental and Biomedical Technology at JPL's Center for Space Microelectronics Technology. The thrust of his programme was the design, and flight validation of microdevices and sensors for monitoring atmospheric constituents and for detection of life.

Presently, Dr. Dastoor serves as the Senior Advisor to the Associate Administrator of Aerospace Technology.

A handful of self made carbon tubes. My dream realized!!

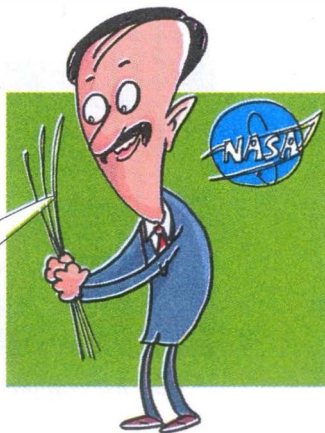


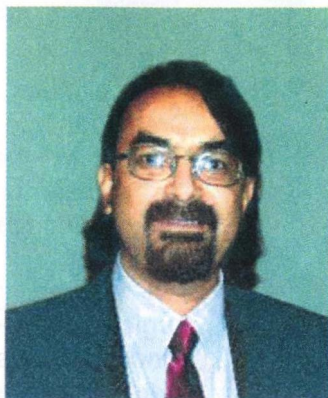
## STAR FACT

### New Hope

**Nanotechnology offers new hope in the field of cancer detection. A device has been developed that is able to detect very low concentrations of protein cancer markers in blood, enabling diagnosis of the disease in its earliest stages.**

● **Dev Nath**





*Dr. Deepak Srivastava*

### **What is the role of Dr. Deepak Srivastava at NASA?**

**D**r. Deepak Srivastava is a Senior Scientist and Technical Leader of Computational Nanotechnology Investigation at NASA Ames Research Center.

Dr. Srivastava has more than ten years of experience in large scale modeling and simulations of nanomaterials, processes, and applications.

Over the past ten years, he has worked as the Senior Lead Scientist and Group Leader of Computational Materials Design and Nanotechnology at NASA Ames.

In recent years, he has given about 100 presentations on Carbon nanotubes and nanotechnology. He has authored or co-authored about 65 technical papers.





*Dr. Pulickal Ajayan*

---

## Why is Dr. Pulickal Ajayan famous?

A pioneer in nanotechnology, Dr. Ajayan has been one of the key figures in the development of carbon nanotube technologies. His early education was in Kerala, India.

He earned his B. Tech in metallurgical engineering from Banaras Hindu University, and Ph.D. in materials science and engineering from Northwestern University, USA, in 1989. He joined the mechanical engineering and materials science department of Rice University, as a professor in Engineering from July 2007.

Professor Ajayan's research interests include synthesis and structure-property relations of nanostructures and nanocomposites, layered materials, science and applications of nanomaterials, energy storage, and phase stability in nanoscale systems.

He has won several awards, published one book, and 370 journal papers. Professor Ajayan has given more than 250 invited talks including several keynote and plenary lectures in several countries as well.

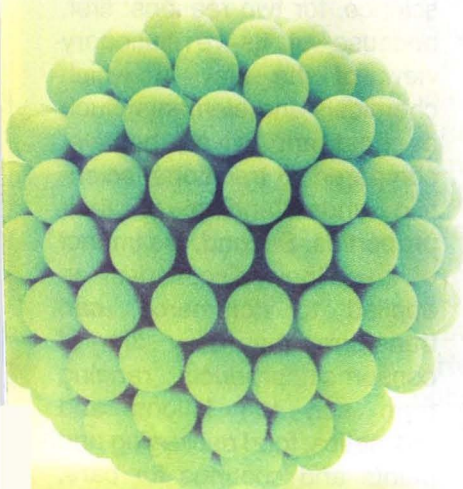


## DISADVANTAGES OF nanotechnology

**What are the advantages and disadvantages of nanotechnology for commerce?**

Nanotechnology has been heralded as a 'revolution' in science, for two reasons: first, because of its revolutionary view of the way in which chemicals and elements, such as gold and silver, behave, compared to traditional scientific understanding of their properties. Second, the impact of these new discoveries, as applied to commerce, can transform the daily life of consumer products ranging from sun tan lotions and cosmetics, food packaging and paints and coatings for cars, housing and fabrics, medicine and thousands of industrial processes.

It is true that nanotechnology is an exciting new field opening up vast possibilities in different areas, but it also poses several problems as far as commerce is concerned. Diamonds will become cheaper, causing a market crash in this commodity. Advances in nanotechnology can develop alternate sources of energy, and this will lower the cost of oil, causing a worldwide market crash.



## STAR FACT

### Quantum Teleportation

**Teleportation is a mode of instantaneous transportation in which matter is dematerialized at one place, and recreated at another. Right now, it exists only in books, and imagination. However, some work has been done on quantum teleportation in which information or the exact state of an atom or photon, can be transmitted a short distance from one location to another.**



An abstract graphic on the left side of the page. It features a series of white dots arranged in a curved, spiral-like pattern. From these dots, numerous thin, light blue lines radiate outwards, creating a fan-like or sunburst effect. The background is a solid, deep blue.

## Why does nanotechnology pose several threats?

**T**iny nanomaterials are hidden in many of the products we use every day.

Nanoscale materials dissolve in different ways, take on different magnetic properties, react differently to chemicals, or reflect light differently from the way they would at normal size. The very qualities that make nanomaterials commercially desirable can also make them more toxic than their normal-size counterparts.

Because they are so small—the head of a pin is about 1 million nanometres across—nanomaterials can be extremely mobile. They may pass easily into the bloodstream when inhaled or swallowed, and possibly, when applied to the skin. Once inside the body, they seem to have access to most or all tissues and organs, including the brain.

Nanotechnology as a weapon, can be very dreadful if it is in the hands of terrorists. Biological and chemical weapons will replace nuclear weapons, and they can sweep away many nations at a time. To sum up, nanotechnology has great promise, but there are still many questions to be answered about how safe and how desirable it is.



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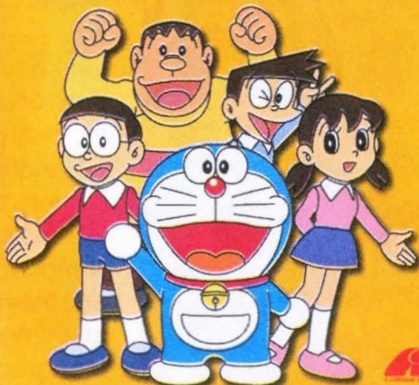
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# Clarifications & Corrections

Chaithanya S. Vinu, a student from Meenambalpuram, Tamil Nadu, has pointed out a mistake in the May issue of Tell Me Why, Explorations. She writes that, on page 31, it is given that, Christopher Columbus set sail to China but reached America, which is not correct. In fact, Columbus set sail to India, greedy for wealth, just like many of his contemporaries.



*James Clark Ross*



*John Ross*

N. Shriram, a student of class 8, SJNS Jadavbai Jain Higher Secondary School, Chennai, points out that in the May issue of Tell Me Why - Explorations, that on page 92, the photograph of John Ross is wrongly captioned as James Clark Ross.

*Thank you Chaithanya and Shriram for your valuable feedbacks. Pictures of both the explorers are shown above with correct captions.*

*- Editor*



# NANO DICTIONARY

**Atomic Force Microscope (AFM):** A microscope used in nanotechnology. It does not use light, but functions by the force between the atoms in the sample.

**Bottom-up:** Building larger objects from smaller building blocks. Eg; Construction of machines using atoms and molecules.

**Buckminsterfullerene:** A variety of buckyballs and carbon nanotubes. It is named after the architect, Buckminster Fuller, famous for designing the geodesic dome.

**Buckyball:** A molecule made up of 60 carbon atoms, arranged in hexagonal shapes like a soccer ball.

**Carbon nanotube:** A cylinder-shaped structure resembling a rolled up sheet of graphite.

**Fullerene:** A third form of carbon, after diamond and graphite.

**Gray Goo:** A mass of destructive nanorobots, with the capacity to wipe out all life.

**Lithography:** The process of copying a feature onto a surface using light, electron beams or X-rays.

**MEMS:** Micro Electromechanical Systems used in integrated circuits.

**Nanobots:** Small self-replicating nanorobots.

**Nanites:** Machines with atom-sized components.

**Nanocrystals:** Nanoscale semiconductor crystals, typically about 10 nm in diameter.

**Nanoscale:** 1-100 nm range

**Quantum computer:** A computer based on quantum bits that can represent any combination of one and zero.

**Quantum dots:** Nanometre-sized semiconductor crystals.

**Scanning tunnelling microscope:** A machine used in nanotechnology. It uses the beams of electron to scan the surface of a cell.

**Self-assembly:** Resulted from the random motion of molecules and the affinity of their binding sites.

**Semiconductor:** A substance such as silicon, which conducts electricity under certain circumstances.

**Superconductor:** A material through which electricity is conducted without any resistance.

**Top-down:** The building of small objects using larger items. An approach used in nanotechnology.



# I Wonder Why?

## Question of the Month

### What makes popcorn pop?

A popcorn kernel is actually a seed. It has a tiny plant embryo in its centre, which is surrounded by a soft and starchy material that contains water. The embryo is again surrounded by a hard shell named hull. As the popcorn is heated, the water turns into steam, which builds pressure inside the hull. When the hull can no longer contain the pressure, the kernel explodes, and a fluffy new ball of popcorn is born, that too, within seconds. Isn't it amazing?

● *Indhu Thomas*

Question sent by:

**Ankita Mishra**, Ghaziabad, UP.

---

Send us your questions

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## WINNERS

Winners of the **GK Contest - 12, Heritage Sites** held in the May issue of Tell Me Why.

**1. Ashrith N. Raj**

Jawahar Navodaya Vidyalaya, Galibeedu,  
Kodagu, Karnataka.

**2. Nitesh Kakkar**

H-60, Reserve Bank Officers Quarters,  
Poorvi Marg, Vasant Vihar, New Delhi

**3. Abhay P.J.**

Niranjana, Chembukavu,  
Thrissur, Kerala.

**4. A. Sahitya**

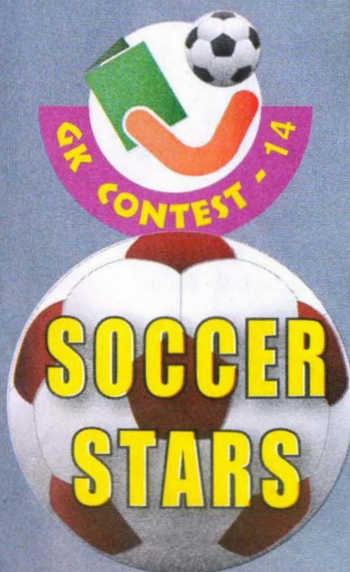
No.3, Type III,  
Kendriya Vidyalaya,  
Staff Qtrs, University Campus,  
Puducherry.

**5. Ayushee Sinha**

152/1/1, Nimtala Ghat Road,  
Shyamnagar, Dist - 24 Pgs (N),  
West Bengal.

## GK Contest -12 Heritage Sites - ANSWERS

1. Mahabodhi Temple, Bodh Gaya
2. Qutub Minar, Delhi
3. Stone Chariot, Hampi
4. Sanchi Stupa, Sanchi
5. Red Fort, Delhi
6. Humayun's Tomb, Delhi



Here's a contest for our readers. Identify the footballers, from the photos given here.

All you need to do is send us an email naming each one with the proper number.

(PLEASE GIVE YOUR POSTAL ADDRESS ALSO IN THE E-MAIL) You are also welcome to send your answers by post.

Five winners will be awarded prizes. In case there are more than five correct entries, the winners will be chosen by lot.

**Last Date to receive entries:**

**2014 JULY 25<sup>th</sup>**

Our e-mail address:

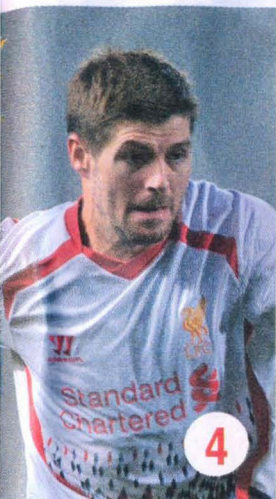
**childrensdivision@mmp.in**

Please enter

**TMW - GK CONTEST - 14**

in the subject line of your email.





FOR FIVE LUCKY WINNERS

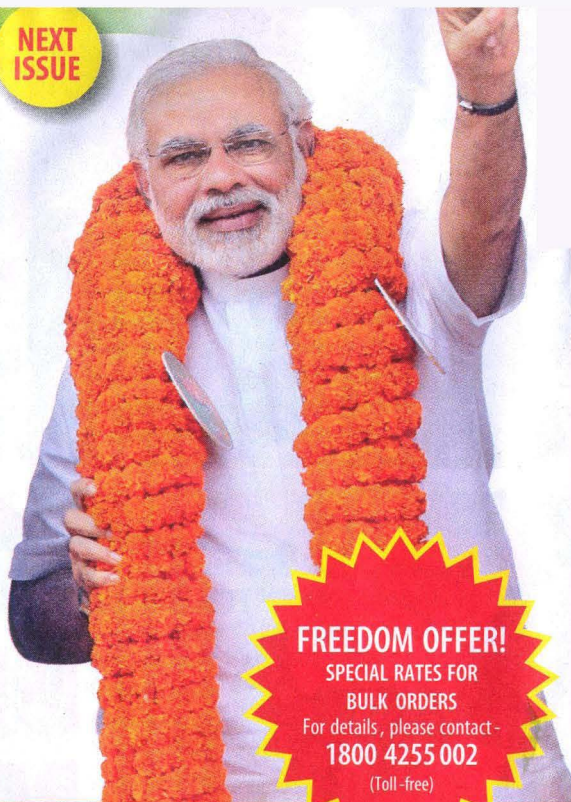
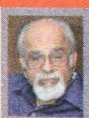
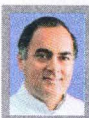
# MICRO ROBOT

If you are sending your entry by post,  
superscribe this on your envelope.

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**MANORAMA TELL ME WHY - NANOTECHNOLOGY**

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